CONSTRUCTOR
UNIVERSITY

Study Program Handbook

Chemistry and Biotechnology

Bachelor of Science

Subject-specific Examination Regulations for Chemistry and Biotechnology (Fachspezifische Prüfungsordnung)

The subject-specific examination regulations for Chemistry and Biotechnology are defined by this program handbook and are valid only in combination with the General Examination Regulations for Undergraduate degree programs (General Examination Regulations = Rahmenprüfungsordnung). This handbook also contains the program-specific Study and Examination Plan (Chapter 6).

Upon graduation, students in this program will receive a Bachelor of Science (BSc) degree with a scope of 180 ECTS (for specifics see Chapter 4 of this handbook).

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1 Program Overview

1.1 Concept

1.1.1 The Constructor University Educational Concept

Constructor University aims to educate students for both an academic and a professional career by emphasizing three core objectives: academic excellence, personal development, and employability to succeed in the working world. Constructor University offers an excellent research driven education experience across disciplines to prepare students for graduate education as well as career success by combining disciplinary depth and interdisciplinary breadth with supplemental skills education and extra-curricular elements. Through a multi-disciplinary, holistic approach and exposure to cutting-edge technologies and challenges, Constructor University develops and enables the academic excellence, intellectual competences, societal engagement, professional and scientific skills of tomorrows leaders for a sustainable and peaceful future.

In this context, it is Constructor University's aim to educate talented young people from all over the world, regardless of nationality, religion, and material circumstances, to become citizens of the world who can take responsible roles for the democratic, peaceful, and sustainable development of the societies in which they live. This is achieved through high-quality teaching, manageable study loads and supportive study conditions. Study programs and related study abroad programs convey academic knowledge as well as the ability to interact positively with other individuals and groups in culturally diverse environments. The ability to succeed in the working world is a core objective for all study programs at Constructor University, both in terms of actual disciplinary subject matter and social skills and intercultural competence. Study-program-specific modules and additional specializations provide the necessary depth, interdisciplinary offerings and the minor option provide breadth while the university-wide general foundation and methods modules, optional German language and Humanities modules, and an extended internship period strengthen the employability of students. The concept of living and learning together on an international campus with many cultural and social activities supplements students' education. In addition, Constructor University offers professional advising and counseling.

Constructor University's educational concept is highly regarded both nationally and internationally. While the university has consistently achieved top marks over the last decade in Germany's most comprehensive and detailed university ranking by the Center for Higher Education (CHE), it has also been listed by one of the most widely observed university rankings, the Times Higher Education (THE) ranking. More details on the current ranking positions can be found at https://constructor.university/more/about-us.

1.1.2 Program Concept

Chemistry is the scientific discipline involved with elements and compounds composed of atoms, molecules, and ions, and it studies their composition, structure, behavior, and the changes they undergo during a reaction with other substances. Biotechnology is the application of biology to the solution of real-life challenges, where an element of profit is a prerequisite. The two disciplines are connected by their molecular approach and by their vast commercial importance. Both chemistry and biotechnology relate to many aspects of human life. They lie at the heart of some of the world's most advanced industries, for example, those producing goods, materials, fuels, or pharmaceuticals, as well as those focusing on sustainable energy development and even food and beverage. In particular, the chemical industry is rapidly transforming into a bio-based industry in line with the evolution of modern societies towards bio-based economies founded on sustainability and zero CO_2 emission. Fostering the synergies between chemistry and biotechnology is expected to strongly facilitate groundbreaking innovations and develop solutions for mankind's most urgent and foreseeable problems: energy, environment, food, and health. The study program Chemistry and Biotechnology (CBT) at Constructor University supports this synergy already at the level of undergraduate education. The CBT program follows the guidelines of the GDCh[1] and the DECHEMA e.V.[2] GDCh is the central organization of chemistry in Germany and has published suggestions for studies in chemistry. DECHEMA e.V. is an expert network for chemical engineering and biotechnology.

At Constructor University, we equip our CBT students with the knowledge, research techniques, and problem-solving skills necessary for a career in chemistry and/or biotechnology, and for further studies at the Master or PhD level. Simultaneously, we support their careers in the public or private sector, in research or management. The transdisciplinary CBT study program offers chemistry modules that include organic, inorganic, analytical, and physical chemistry; students are also taught the relevant aspects of mathematics, engineering, and industrial practice. The focus of biotechnology in this study program is to learn how industry can take advantage of biocatalysts and biomolecules in order to contribute to a more sustainable future. Biorefining, i.e the uses of renewable rather than fossil resources, is another major aspect of CBT; this will introduce students to the concept and practice of the "circular economy."

Early access to research is another central aspect of CBT. Over the course of the three-year study program, students take extensive laboratory courses and conduct their own research projects during their third year of study. Undergraduate students are strongly encouraged to engage in research projects with graduate students as early as their first or second semester at Constructor University. Past students have contributed to and co-authored published journal articles by Constructor University professors and their research groups.

As a consequence, students graduating with a B.Sc. degree in CBT from Constructor University are in an excellent position to specialize in any field of chemistry, and additionally in the fields of chemical and industrial biotechnology, pharmaceutical and food technology, applied microbiology, or synthetic biology.

1 https://www.gdch.de/fileadmin/downloads/Ausbildung_und_Karriere/Schule_Studium_Ausbildung/PDF/GDCh_Studienkommission_2015.pdf

2 https://dechema.de/Empfehlungen_Ausbildung_Biotechnologie.html?highlight=Studium+Biotechnologie+Lehre

1.2 Specific Advantages of CBT at Constructor University

- Combining chemistry and biotechnology in an undergraduate program is relatively recent, and Constructor University is one of the few universities that offer this path. The connections and synergies between these fields become clear to the students already within the first year of study. Students also obtain an overview very early on of how these scientific fields affect society; this helps them to identify their own area of interest.
- Due to the combination of the two scientific fields, CBT students will be particularly strong in recognizing the potential of combining chemical catalysis with bioconversions in the context provided by established industrial sectors or in the creation of innovative approaches.

- The CBT program has a very strong practical component with excellent laboratory courses. This helps students gain the hands-on experience that they need to apply for high-level internships and graduate school positions. The Bachelor thesis consists of research work in the research groups of the Faculty in the Department of Life Sciences and Chemistry. The research carried out by CBT students regularly results in co-authorships of scientific publications.
- While the CBT program covers undergraduate education in Chemistry and Biotechnology, the broad experience of Constructor University Life Sciences and Chemistry Faculty and the courses they offer also allow students to explore related subjects such as biophysics, bioinformatics, medicinal chemistry, chemical biology, drug design, marine science, food analytics, molecular immunology, biochemistry, cell biology, microbiology, and others.
- While the CBT program is essentially of an academic nature, students are exposed to practical aspects impacting industrial practice. They learn the fundamentals of engineering and economics that allow them to effectively communicate across a variety of professional roles and industries.

1.3 Program-Specific Educational Aims

1.3.1 Qualification Aims

The CBT program prepares students for an academic or professional career in the fields of Chemistry and/or Biotechnology:

- Throughout their studies, CBT students acquire profound and comprehensive theoretical knowledge in the fields of general, inorganic, and organic chemistry, biochemistry, microbiology, genetics, molecular biology, industrial microbiology, and process science, thereby gaining a thorough understanding of the principal concepts in these research and application areas. Furthermore, students learn how to abstract and transfer their knowledge to new research areas, an essential skill in the modern life sciences.
- Presentation skills are developed through scientific poster preparation and oral presentations. In this context, students are exposed to primary scientific literature.
- The theoretical education is complemented by practical training in laboratory courses in all the fields of the CBT major, both within chemistry and within biotechnology. In these courses, students acquire excellent technical skills and employ state-of-the-art methods. In addition, they learn how to accurately document and analyze scientific data through the writing of Laboratory reports and the Bachelor thesis, all following publication-style rules.
- Through their involvement in research conducted at Constructor University, students experience an authentic research environment that also teaches them to adhere to ethical standards and good laboratory practice. They further learn how to develop and defend their individual research project, and they acquire an early perspective on prospective careers.
- Intensive teamwork in laboratory courses and within research groups enables students to take responsibility for their own work, and they also learn how to constructively engage in international teams in an atmosphere of mutual acceptance and respect. Consequently, CBT graduates have acquired a high communication competence. They are aware of intercultural differences and possess skills to deal with the challenges of a global job market.

1.3.2 Intended Learning Outcomes

By the end of the study program, students will be able to:

A: Chemistry and Biotechnology Related Knowledge

B: Chemistry and Biotechnology Related Intellectual Skills

C: Chemistry and Biotechnology Related Practical Skills

D: Transferable Skills

In each of these four fields, students will, by the end of the study program, be able to:

A1. recognize the fundamental properties, structures, and reactivity of chemical substances;

A2. explain the fundamental facts, principles, and theories for the principal areas of chemistry (analytical, organic, inorganic, and physical);

A3. apply physical principles to chemical and biotechnological concepts;

A4. recognize basic biochemical patterns of the structure and reactivity of molecules in nature;

A5. apply calculational tools to quantitative problems in Chemistry and Biotechnology;

A6. explain the concept of biomolecules and the use of biocatalysts for the synthesis of useful chemicals;

A7. identify possibilities to manipulate genes, enzyme activities, and metabolic pathways;

A8. explain the structure and genetic modification of microorganisms;

B1. apply chemical principles to formulate and analyze analytical and synthetic chemical problems;

B2. analyze and interpret experimental data, critically assess data in literature, and extract useful data from it;

B3. carry out directed research by selecting appropriate topics and procedures, and present the results;

B4. demonstrate appreciation of chemical and biotechnological topics relevant to environmental issues;

B5. use their knowledge to view issues in chemistry and biotechnology from a global perspective;

B6. reflect on the consequences of chemical and biotechnological activities on humanity and the environment;

C1. assess and manage the risks of chemical substances and laboratory procedures by evaluating their potential impact on the environment and the experimenter;

C2. assess and manage the risks of gene-modified organisms by evaluating their potential impact on the environment and the experimenter;

C3. conduct standard laboratory procedures involved in synthetic, analytic, and instrumental work;

C4. operate a range of chemical and biotechnological instrumentation with adequate hands-on experiences;

D1. communicate effectively both orally and in writing with professionals and/or a lay audience;

D2. possess information technology skills, especially in the areas of information retrieval, literature search, and the use of library databases;

D3. work independently and collaborate effectively with other people in a team;

D4. self-evaluate their own learning progress, and develop motivation and learning skills for lifelong learning.

1.4 Career Options and Support

Career opportunities for CBT students are diverse and abundant. In general, the combination of chemistry and biotechnology increases employability, since biotechnological applications in chemical industry are increasingly important. Sustainability and environmental protection are topics of ever increasing importance in society and industry. In research and development, career opportunities cover the areas of chemicals, pharmaceuticals, fuels, nanotechnology, materials, and energy, to environmental monitoring and forensic science.

The educational concept of Constructor University aims at fostering employability which refers to skills, capacities, and competencies that transcend disciplinary knowledge and allow graduates to quickly adapt to professional contexts. Constructor University defines employability as encompassing, i.e., it focuses not only on technical skills and understanding but also on personal attributes, competencies, and qualities that enable students to become responsible members of their professional and academic fields as well as of the societies they live in.

Graduates of Constructor University are equipped with the ability to find employment and to pursue a successful professional career, which means that graduates will be able to:

- acquire knowledge rapidly, and gather, evaluate, and interpret relevant information, and evaluate new concepts critically to derive scientifically founded judgements;
- apply their knowledge, understanding and methodological competences to their activity or profession to solve problems;
- present themselves and their ideas effectively;
- take responsibility for their own and their team's learning and development.

Graduates of Constructor University are also equipped with a foundation to become globally responsible citizens, which includes the following attributes and qualities:

- Graduates have gained intercultural competence, and are aware of intercultural differences and possess skills to deal with intercultural challenges; they are familiar with the concept of tolerance;
- Graduates can rely on basic civic knowledge, are able to analyze global issues of an economic, political, scientific, social, or technological nature, and are able to evaluate situations and make decisions based on ethical considerations;
- Graduates are able and prepared to take responsibility for their professional community and society.

The Career Service Center (CSC) helps students in their career development. It provides students with high-quality training and coaching in CV creation, cover letter formulation, interview preparation, effective presenting, business etiquette, and employer research as well as in many other aspects, thus helping students identify and follow up on rewarding careers after graduating from Constructor

University. Furthermore, the Alumni Office helps students establish a long-lasting and global network which is useful when exploring job options in academia, industry, and elsewhere.

1.5 Admission Requirements

Admission to Constructor University is selective and based on a candidate's school and/or university achievements, recommendations, self-presentation, and performance on standardized tests. Students admitted to Constructor University demonstrate exceptional academic achievements, intellectual creativity, and the desire and motivation to make a difference in the world.

The following documents need to be submitted with the application:

- Recommendation Letter (optional)
- Official or certified copies of high school/university transcripts
- Educational History Form
- Standardized test results (SAT/ACT) if applicable
- Motivation statement
- ZeeMee electronic resume (optional)
- Language proficiency test results (TOEFL Score: 90, IELTS: Level 6.5 or equivalent)

Formal admission requirements are subject to higher education law and are outlined in the Admission and Enrollment Policy of Constructor University.

For more detailed information about the admission visit: https://constructor.university/admission-aid/application-information-undergraduate

1.6 More information and contacts

For more information on the study program please contact the Study Program Coordinator:

Prof. Dr. Detlef Gabel
Professor of Chemistry
Email: dgabel@constructor.university

Prof. Dr. Ulrich Kortz
Professor of Chemistry
Email: ukortz@constructor.university

or visit the program website: https://constructor.university/programs/undergraduate-education/chemistry-biotechnology

For more information on Student Services please visit:

https://constructor.university/student-life/student-services

2 The Curricular Structure

2.1 General

The curricular structure provides multiple elements for enhancing employability, interdisciplinarity, and internationality. The unique CONSTRUCTOR Track, offered across all undergraduate study programs, provides comprehensive tailor-made modules designed to achieve and foster career competency. Additionally, a mandatory internship of at least two months after the second year of study and the possibility to study abroad for one semester give students opportunities to gain insight into the professional world, apply their intercultural competences and reflect on their roles and ambitions for employment and in a globalized society.

All undergraduate programs at Constructor University are based on a coherently modularized structure, which provides students with an extensive and flexible choice of study plans to meet the educational aims of their major as well as minor study interests and complete their studies within the regular period.

The framework policies and procedures regulating undergraduate study programs at Constructor University can be found on the website (https://constructor.university/student-life/student-services/university-policies)

2.2 The Constructor University 4C Model

Constructor University offers study programs that comply with the regulations of the European Higher Education Area. All study programs are structured according to the European Credit Transfer System (ECTS), which facilitates credit transfer between academic institutions. The three-year undergraduate programs involve six semesters of study with a total of 180 ECTS credit points (CP). The undergraduate curricular structure follows an innovative and student-centered modularization scheme, the 4C Model. It groups the disciplinary content of the study program in three overarching themes, CHOICE-CORE-CAREER according to the year of study, while the university-wide CONSTRUCTOR Track is dedicated to multidisciplinary content dedicated to methods as well as intellectual skills and is integrated across all three years of study. The default module size is 5 CP, with smaller 2.5 CP modules being possible as justified exceptions, e.g., if the learning goals are more suitable for 2.5 CP and the overall student workload is balanced.

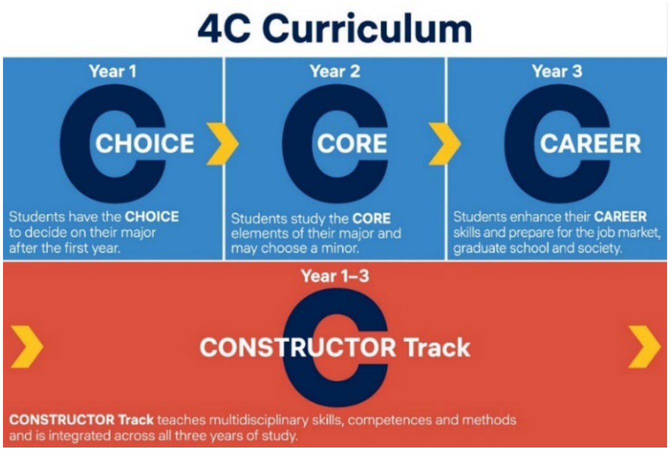

Figure 1: The Constructor University 4C-Model

2.2.1 Year 1 – CHOICE

The first study year is characterized by a university-specific offering of disciplinary education that builds on and expands upon the students' entrance qualifications. Students select introductory modules for a total of 45 CP from the CHOICE area of a variety of study programs, of which 15-45 CP will belong to their intended major. A unique feature of our curriculum structure allows students to select their major freely upon entering Constructor University. The team of Academic Advising Services offers curriculum counseling to all Bachelor students independently of their major, while Academic Advisors, in their capacity as contact persons from the faculty, support students individually in deciding on their major study program.

To pursue Chemistry and Biotechnology (CBT) as a major, the following CHOICE modules (30 CP) are mandatory (m):

- CHOICE Module: General and Inorganic Chemistry (m, 7.5 CP)
- CHOICE Module: General Biochemistry (m, 7.5 CP)
- CHOICE Module: Introduction to Biotechnology: Microbiology and Genetics (m, 7.5 CP)
- CHOICE Module: General Organic Chemistry (m, 7.5 CP)

The remaining CHOICE modules (15 CP) can be selected in the first year of study according to interest and/or with the aim of allowing a change of major until the beginning of the second year, when the major choice becomes fixed.

We highly recommend the module 'General Cell Biology' (me, 7.5 CP) to deepen knowledge in life sciences.

Students can still change to another major at the beginning of their second year of studies, provided they have taken the corresponding mandatory CHOICE modules in their first year of studies. All students must participate in an entry advising session with their Academic Advisors to learn about their major change options and consult their Academic Advisor prior to changing their major.

Students that would like to retain a further option are strongly recommended to additionally register for the CHOICE modules of one of the following study programs in their first year:

- Biochemistry and Cell Biology (BCCB)
  CHOICE Module: General Biochemistry (m, 7.5 CP)
  CHOICE Module: General Cell Biology (m, 7.5 CP)
  CHOICE Module: General and Inorganic Chemistry (m, 7.5 CP)
  CHOICE Module: General Organic Chemistry (m, 7.5 CP)

- Medicinal Chemistry and Chemical Biology (MCCB)
  CHOICE Module: General Medicinal Chemistry and Chemical Biology (m, 7.5 CP)
  CHOICE Module: General Organic Chemistry (m, 7.5 CP)
  CHOICE Module: General Biochemistry (m, 7.5 CP)
  CHOICE Module: General Cell Biology (m, 7.5 CP)

- Integrated Social and Cognitive Psychology (ISCP)
  CHOICE Module: Essentials of Cognitive Psychology (7.5 CP)
  CHOICE Module: Essentials of Social Psychology (7.5 CP)

- International Relations: Politics and History (IRPH)
  CHOICE Module: Introduction to International Relations Theory (7.5 CP)
  CHOICE Module: Introduction to Modern European History (7.5 CP)

2.2.2 Year 2 – CORE

In their second year, students take with a total of 45 CP from a selection of in-depth, discipline-specific CORE modules. Building on the introductory CHOICE modules and applying the methods and skills acquired so far (see 2.3.1), these modules aim to expand the students' critical understanding of the key theories, principles, and methods in their major for the current state of knowledge and best practice.

To pursue CBT as a major, the following 45 CP of CORE modules need to be taken:

- CORE Module: Physical Chemistry (m, 5 CP)
- CORE Module: Industrial Biotechnology (m, 5 CP)
- CORE Module: Advanced Inorganic Chemistry (m, 5 CP)
- CORE Module: Scientific Software and Databases (m, 5 CP)
- CORE Module: Advanced Organic and Analytical Chemistry Lab (m, 5 CP)
- CORE Module: Advanced Organic Chemistry (m, 5 CP)
- CORE Module: Bioprocess Engineering (m, 5 CP)
- CORE Module: Advanced Biotechnology Lab (m, 5 CP)
- CORE Module: Inorganic/Physical Chemistry Lab (m, 5 CP)

For students pursuing a minor in another study program (see below) the modules Scientific Software and Databases and Advanced Biotechnology Lab can be replaced by modules of the minor study program. The module Advanced Biotechnology Lab has to be then taken in the third year as a specialization module.

CBT students can take CORE modules (or more advanced Specialization modules) from a second discipline, which allows them to incorporate a minor study track into their undergraduate education, within the 180 CP required for a bachelor's degree. The educational aims of a minor are to broaden the students' knowledge and skills, support the critical reflection of statements in complex contexts, foster an interdisciplinary approach to problem-solving, and to develop an individual academic and professional profile in line with students' strengths and interests. This extra qualification will be highlighted in the transcript.

The Academic Advising Coordinator, Academic Advisor, and the Study Program Chair of the minor study program support students in the realization of their minor selection; the consultation with the Academic Advisor is mandatory when choosing a minor.

As a rule, a minor in another field of study requires a CBT student to:

- take mandatory CHOICE modules (15 CP) from the desired minor program in the first year
- substitute the mandatory elective CBT CORE modules "Scientific Software and Databases" and “Advanced Biotechnology Lab” and the mandatory elective METHODS module “Plant Metabolism and Natural Products” in the second year (15 CP in total) with the minor CORE or Specialization modules of the minor study program. The module “Advanced Biotechnology

Lab” must be taken in the third year when selecting the minor option (see Specialization Modules below).

The requirements for each specific minor are described in the handbook of the study program offering the minor (chapter 3.2) and are marked in the respective Study and Examination Plans. An overview of accessible minors is found in the Major/Minor Combination Matrix which is published at the beginning of each academic year.

2.2.3 Year 3 – CAREER

During their third year, students prepare and make decisions for their career after graduation. To explore available choices fitting individual interests, and to gain professional experience, students take a mandatory summer internship (see 2.2.3.1). The third year of studies allows CBT students to further sharpen their profile with a selection of discipline-specific, research-oriented specialization modules that can be combined to enhance their individual competences in the natural sciences, strategy development for novel research approaches or managerial capabilities. Furthermore, the third year also focuses on the responsibility of students beyond their discipline (see CONSTRUCTOR Track).

The fifth semester also opens a mobility window for a diverse range of study abroad options. Finally, the sixth semester is dedicated to fostering the students’ research experience by involving them in a Bachelor thesis project.

2.2.3.1 Internship / Start-up and Career Skills Module

As a core element of Constructor University’s employability approach students are required to engage in a mandatory two-month internship of 15 CP that will usually be completed during the summer between the second and third years of study. This gives students the opportunity to gain first-hand practical experience in an external professional research environment, apply their knowledge and understanding in the context of an external institution, reflect on the relevance of their major to employment and society, reflect on their own personal role, and further develop their professional orientation. The internship can establish valuable contacts for the students’ bachelor’s thesis project, for the selection of a master program or graduate school, or for further employment after graduation. This module is complemented by career advising and several career skills workshops throughout all six semesters that prepare students for the transition from student life to professional life. As an alternative to the full-time internship, students interested in setting up their own company can apply for a start-up option to focus on developing their business plans.

For further information, please contact the Career Service Center (CSC) (https://constructor.university/student-life/career-services)

For organizational aspects consult with your Academic Advisor and the CBT SPC for reasonable choices to conduct a prosperous internship.

2.2.3.2 Specialization Modules

In the third year of their studies, students take 15 CP from major-specific or major-related, advanced Specialization Modules to consolidate their knowledge and to be exposed to state-of-the-art research in the areas of their interest. This curricular component is offered as a portfolio of modules, from which students can make free selections during their fifth and sixth semester. The default Specialization Module size is 5 CP, with smaller 2.5 CP modules being possible as justified exceptions.

To pursue CBT as a major, at least 10 of the 17.5 CP from the following major-specific Specialization Modules need to be taken:

- CBT Specialization: Organometallic Chemistry (me, 5 CP)
- CBT Specialization: Environmental Microbiology and Biotechnology (me, 5 CP)
- CBT Specialization: Biotechnology in Action (me, 5 CP)
- CBT Specialization: Fluorine in Organic Synthesis (me, 2.5 CP)

A maximum of 5 CP can be taken from major-related modules instead of major-specific Specialization Modules:

- MCCB Specialization: Advanced Organic Synthesis (me, 5 CP)
- MCCB CORE: Medicinal Chemistry (me, 5 CP)

Students may also select 15 CP entirely from their major-specific Specialization Modules. For detailed information on the contents of the Specialization modules, the reader is referred to the respective module descriptions.

Students pursuing a minor (see above) must take the CORE module Advanced Biotechnology Lab (m, 5 CP) instead of a specialization module.

2.2.3.3 Study Abroad

Students have the opportunity to study abroad for a semester to extend their knowledge and abilities, broaden their horizons and reflect on their values and behavior in a different context as well as on their role in a global society. For a semester abroad (usually the fifth semester), modules related to the major with a workload equivalent to 22.5 CP must be completed. Modules recognized as study abroad CP need to be pre-approved according to Constructor University's study abroad procedures. Several exchange programs allow students to directly enroll at prestigious partner institutions worldwide. Constructor University's participation in Erasmus+, the European Union's exchange program, provides an exchange semester at a number of European universities that include Erasmus study abroad funding.

For further information, please contact the International Office

(https://constructor.university/student-life/study-abroad/international-office)

CBT students that wish to pursue a study abroad in their fifth semester are required to select their modules at the study abroad partners such that they can be used to substitute between 10-15 CP of major-specific Specialization modules and between 5-15 CP of modules equivalent to the non-disciplinary New Skills modules (see CONSTRUCTOR Track). In their sixth semester, according to the study plan, returning study-abroad students complete the Bachelor Thesis/Seminar module (see next section), they take any missing Specialization modules to reach the required 15 CP in this area, and they take any missing New Skills modules to reach the required 15 CP in this area.

2.2.3.4 Bachelor Thesis/Seminar Module

This module is a mandatory graduation requirement for all undergraduate students. It consists of two module components in the major study program guided by a Constructor University faculty member: the Bachelor Thesis (12 CP) and a Seminar (3 CP). The title of the thesis will appear on the students' transcripts.

Within this module, students apply the knowledge, skills, and methods they have acquired in their major discipline to become acquainted with actual research topics, ranging from the identification of suitable (short-term) research projects, preparatory literature searches, the realization of discipline-specific research, and the documentation, discussion, and interpretation of the results. The data will be analyzed and interpreted according to good scientific practice and ethical standards.

With their Bachelor Thesis, students demonstrate mastery of selected contents and methods of the major-specific research field. Furthermore, students show the ability to analyze and solve a well-defined problem with scientific approaches, a critical reflection of the status quo in scientific literature, and the original development of their own ideas. With the permission of a Constructor University Faculty supervisor, the Bachelor Thesis can also have an interdisciplinary nature. In the seminar, students present and discuss their theses in a course environment and reflect on their theoretical or experimental approach and conduct. They learn to present their chosen research topics concisely and comprehensibly in front of an audience and to explain their methods, solutions and results with both specialists and non-specialists.

2.3 The CONSTRUCTOR Track

The CONSTRUCTOR Track is another important feature of Constructor University's educational model. The Constructor Track runs orthogonal to the disciplinary CHOICE, CORE, and CAREER modules across all study years and is an integral part of all undergraduate study programs. It provides an intellectual tool kit for lifelong learning and encourages the use of diverse methodologies to approach cross-disciplinary problems. The CONSTRUCTOR track contains Methods, New Skills and German Language and Humanities modules.

2.3.1 Methods Modules

To pursue CBT as a major, the following Methods modules (20 CP) must be taken as mandatory modules:

- Methods Module: Mathematical Concepts for the Sciences (m, 5 CP)
- Methods Module: Physics for the Natural Sciences (m, 5 CP)
- Methods Module: Analytical Methods (m, 5 CP)
- Methods Module: Plant Metabolism and Natural Products (me, 5 CP)

The Module Plant Metabolism and Natural Products can be replaced with a CORE module from another study program in order to pursue a minor.

2.3.2 New Skills Modules

This part of the curriculum constitutes an intellectual and conceptual tool kit that cultivates the capacity for a particular set of intellectual dispositions including curiosity, imagination, critical thought, and transferability. It nurtures a range of individual and societal capacities, such as self-reflection, argumentation and communication. Finally, it introduces students to the normative aspects of inquiry and research, including the norms governing sourcing, sharing, withholding materials and research results as well as others governing the responsibilities of expertise as well as the professional point of view.

All students are required to take the following modules in their second year:

- New Skills Module: Logic (m, 2.5 CP)
- New Skills Module: Causation and Correlation (m, 2.5 CP)

These modules will be offered with two different perspectives of which the students can choose. The module perspectives are independent modules which examine the topic from different point of views. Please see the module description for more details.

In the third year, students take three 5 CP modules that build upon previous modules in the track and are partially constituted by modules that are more closely linked to each student's disciplinary field of study. The following module is mandatory for all students:

- New Skills Module: Argumentation, Data Visualization and Communication (m, 5 CP)

This module will also be offered with two different perspectives of which the students can choose.

In their fifth semester, students may choose between:

- New Skills Module: Linear Model/Matrices (me, 5 CP) and
- New Skills Module: Complex Problem Solving (me, 5 CP).

The sixth semester also contains the choice between two modules, namely:

- New Skills Module: Agency, Leadership and Accountability (me, 5 CP) and
- New Skills Module: Community Impact Project (me, 5 CP).

Students who study abroad during the fifth semester and are not substituting the mandatory Argumentation, Data Visualization and Communication module, are required to take this module during their sixth semester. Students who remain on campus are free to take the Argumentation, Data Visualization and Communication module in person in either the fifth or sixth semester as they prefer.

2.3.3 German Language and Humanities Modules

German language abilities foster students' intercultural awareness and enhance their employability in their host country. They are also beneficial for securing mandatory internships (between the 2nd and 3rd year) in German companies and academic institutions. Constructor University supports its students in acquiring basic as well as advanced German skills in the first year of the CONSTRUCTOR Track. Non-native speakers of German are encouraged to take two German modules (me, 2.5 CP each), but are not obliged to do so. Native speakers and other students not taking advantage of this offering take alternative modules in Humanities in each of the first two semesters:

- Humanities Module: Introduction to Philosophical Ethics (me, 2.5 CP)
- Humanities Module: Introduction to the Philosophy of Science (me, 2.5 CP)
- Humanities Module: Introduction to Visual Culture (me, 2.5 CP)

3 CBT as a Minor

The typical target group aiming at a Minor in CBT are students of the majors BCCB and MCCB with an interest in biotechnology and a deepened understanding of chemistry.

3.1 Qualification Aims

The students learn about physical-chemical laws of broad applications to their own major, deepen their knowledge of bioconversions and their industrial applications in the production of food, chemicals, fuels, and pharmaceuticals, and become familiar with concepts in inorganic chemistry relevant to structure and bonding, metal complexes, and spectroscopic properties.

3.1.1 Intended Learning Outcomes

With a minor in CBT, students are able to:

- Recognize fundamental properties, structures, and the reactivity of inorganic substances
- Apply calculational tools to quantitative problems in Chemistry and Biotechnology
- Explain the concept of biomolecules and the use of biocatalysts for the synthesis of useful chemicals
- Identify possibilities to manipulate genes, enzyme activities, and metabolic pathways

3.2 Module Requirements

A minor in CBT requires 30 CP. The default option to obtain a minor in CBT is marked in the Study and Examination Plans. It consists of the following mandatory CHOICE and CORE modules:

- CHOICE Module: General and Inorganic Chemistry (m, 7.5 CP)
- CHOICE Module: Introduction to Biotechnology: Microbiology and Genetics (m, 7.5 CP)
- CORE Module: Industrial Biotechnology (m, 5 CP)
- CORE Module: Physical Chemistry (m, 5 CP)
- CORE Module: Advanced Inorganic Chemistry (m, 5 CP)

Students from majors other than BCCB or MCCB are strongly advised to have prior knowledge of organic chemistry, biomolecules, and the fundamentals of enzymatic reactions.

3.3 Degree

After successful completion, the minor in CBT will be listed on the final transcript under PROGRAM OF STUDY and BA/BSc – [name of the major] as “(Minor: Chemistry and Biotechnology).”

4 CBT Undergraduate Program Regulations

4.1 Scope of these Regulations

The regulations in this handbook are valid for all students who enter the Chemistry and Biotechnology undergraduate program at Constructor University in Fall 2024. In case of a conflict between the regulations in this handbook and the between the regulations in this handbook and the general Policies for Bachelor Studies, the latter apply (see https://constructor.university/student-life/student-services/university-policies)

In exceptional cases, certain necessary deviations from the regulations of this study handbook might occur during the course of study (e.g., change of the semester sequence, assessment type, or the teaching mode of courses).

In general, Constructor University reserves therefore the right to change or modify the regulations of the program handbook according to relevant policies and processes also after its publication at any time and in its sole discretion.

4.2 Degree

Upon successful completion of the study program, students are awarded a Bachelor of Science degree in Chemistry and Biotechnology.

4.3 Graduation Requirements

In order to graduate, students need to obtain 180 credit points. In addition, the following graduation requirement applies:

Students need to complete all mandatory components of the program as indicated in the Study and Examination Plan in Chapter 6 of this handbook.

5 Schematic Study Plan for CBT

Figure 2 shows schematically the sequence and types of modules required for the study program. A more detailed description, including the assessment types, is given in the Study and Examination Plans in the following section.

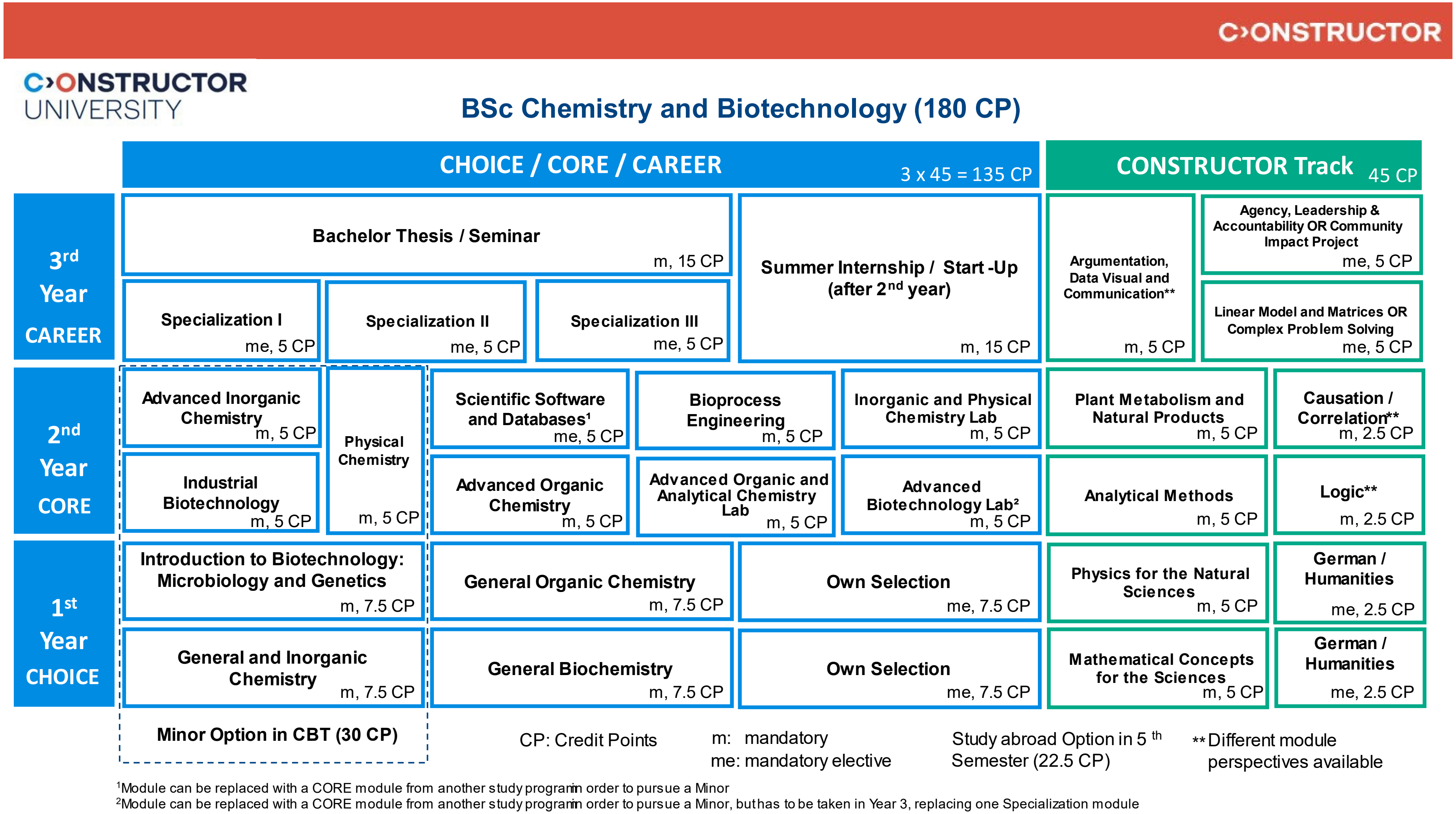

Figure 2: Schematic Study Plan CBT

6 Study and Examination Plan

Chemistry and Biotechnology BSc

Matriculation Fall 2024

	Program-Specific Modules	Type	Assessment	Period	Status[1]	Sem.	CP
Year 1 - CHOICE							**45**
Take the mandatory CHOICE modules listed below. This is a requirement for the CBT program. [2]							
	Unit: Chemistry and Biotechnology *(default minor)*						
CH-120	**Module: General and Inorganic Chemistry** *(default minor)*				m	1	7.5
CH-120-A	General and Inorganic Chemistry	Lecture	Written examination	Examination period			5
CH-120-B	General and Inorganic Chemistry Lab	Lab	Laboratory report	During the semester			2.5
CH-121	**Module: Introduction to Biotechnology: Microbiology and Genetics (default minor)**				m	2	7.5
CH-121-A	Introduction to Biotechnology	Lecture	Written examination	Examination period			5
CH-121-B	Biotechnology Lab	Lab	Written examination	Examination period			2.5
	Unit: Mixed unit (BCCB and MCCB)						
CH-100	**Module: General Biochemistry**				m	1	7.5
CH-100-A	General Biochemistry	Lecture	Written examination	Examination period			5
CH-100-B	General Biochemistry Lab	Lab	Laboratory report	During the semester			2.5
CH-111	**Module: General Organic Chemistry**				m	2	7.5
CH-111-A	General Organic Chemistry	Lecture	Written examination	Examination period			5
CH-111-B	General Organic Chemistry Lab	Lab	Laboratory report	During the semester			2.5
	Unit: CHOICE (own selection)					1/2	15
Take two further CHOICE modules from those offered for all other study programs. [2]							
Year 2 - CORE							**45**
Take all modules listed below or replace mandatory elective ("me") CORE/Methods modules (15 CP) by suitable CORE modules from other study programs. [2]							
	Unit: Inorganic and Physical Chemistry and Industrial Biotechnology						
CO-440	**Module: Physical Chemistry** *(default minor)*				m	3+4	5
CO-440-A	Physical Chemistry	Lecture	Written examination / presentation	Examination period / During the semester		3+4	
CO-441	**Module: Industrial Biotechnology** *(default minor)*				m	3	5
CO-441-A	Industrial Biotechnology	Lecture	Written examination	Examination period			
CO-442	**Module: Advanced Inorganic Chemistry** *(default minor)*				m	4	5
CO-442-A	Advanced Inorganic Chemistry	Lecture	Written examination	Examination period			
	Unit: Organic and Analytical Chemistry (shared with MCCB)						
CO-423	**Module: Advanced Organic Chemistry**				m	3	5
CO-423-A	Advanced Organic Chemistry	Lecture	Written examination	Examination period			
CO-443	**Module: Scientific Software and Databases**				me[3]	4	5
CO-443-A	Scientific Software and Databases	Lecture	Term Paper	During the semester			
CO-424	**Module: Advanced Organic and Analytical Chemistry Lab**				m	3	5
CO-424-A	Advanced Organic Chemistry Lab	Lab	Laboratory report	During the semester			2.5
CO-424-B	Analytical Chemistry Lab	Lab	Laboratory report	During the semester			2.5
	Unit: Advanced Chemistry and Biotechnology						
CO-444	**Module: Bioprocess Engineering**				m	4	5
CO-444-A	Bioprocess Engineering	Lecture	Written examination	Examination period			
CO-445	**Module: Advanced Biotechnology Lab**				m[4]	3	5
CO-445-A	Advanced Biotechnology Lab	Lab	Written examination	During the semester			
CO-446	**Module: Inorganic and Physical Chemistry Lab**				m	4	5
CO-446-A	Inorganic Chemistry Lab	Lab	Laboratory Report	During the semester			2.5
CO-446-B	Physical Chemistry Lab	Lab	Project Assessment	During the semester			2.5

	CONSTRUCTOR Track Modules (General Education)	Type	Assessment	Period	Status[1]	Sem.	CP
Year 1							**15**
	Unit: Methods						10
CTMS-MAT-07	**Module: Mathematical Concepts for the Sciences**				m	1	5
CTMS-07	Mathematical Concepts for the Sciences	Lecture	Written examination	Examination period			
CTMS-SCI-17	**Module: Physics for the Natural Sciences**				m	2	5
CTMS-17	Physics for the Natural Sciences	Lecture	Written examination	Examination period			
	Unit: German Language and Humanities (choose one module for each sememster)				me		5
	German is default language and open to Non-German speakers (on campus and online).[5]						
CTLA-	**Module: German 1**				me	1	2.5
CTLA-	German 1	Seminar	Various	Various			
CTLA-	**Module: German 2**				me	2	2.5
CTLA-	German 2	Seminar	Various	Various			
CTHU-HUM-001	**Humanities Module: Introduction into Philosophical Ethics**				me	2	2.5
CTHU-001	Introduction into Philosophical Ethics	Lecture (online)	Written examination	Examination period			
CTHU-HUM-002	**Humanities Module: Introduction to the Philosophy of Science**				me	1	2.5
CTHU-002	Introduction to the Philosophy of Science	Lecture (online)	Written examination	Examination period			
CTHU-HUM-003	**Humanities Module: Introduction to Visual Culture**				me	2	2.5
CTHU-003	Introduction to Visual Culture	Lecture (online)	Written examination	Examination period			
Year 2							**15**
	Unit: Methods						10
CTMS-SCI-16	**Module: Analytical Methods**				m	3	5
CTMS-16	Analytical Methods	Lecture	Written examination	Examination period			
	Note: The module Plant Metabolites and Natural Products can be replaced with a CORE module from another study program in order to pursue a minor						
CTMS-SCI-18	**Module: Plant Metabolism and Natural Products**				me	4	5
CTMS-18	Plant Metabolism and Natural Products	Lecture	Written examination	Examination period			
	Unit: New Skills						5
Choose one of the two modules							
CTNS-NSK- 01	**Module: Logic (perspective I)**				me	3	2.5
CTNS-01	Logic (perspective I)	Lecture (online)	Written Examination	Examination period			
CTNS-NSK-02	**Module: Logic (perspective II)**				me	3	2.5
CTNS-02	Logic (perspective II)	Lecture (online)	Written Examination	Examination period			
Choose one of the two modules							
CTNS-NSK-03	**Module: Causation and Correlation (perspective I)**				me	4	2.5
CTNS-03	Causation and Correlation (perspective I)	Lecture (online)	Written Examination	Examination period			
CTNS-NSK-04	**Module: Causation and Correlation (perspective II)**				me	4	2.5
CTNS-04	Causation and Correlation (perspective II)	Lecture (online)	Written Examination	Examination period			

Year 3 - CAREER							**45**
CA-INT-900	**Module: Internship / Startup and Career Skills**				**m**	**4/5**	**15**
CA-INT-900-0	Internship / Startup and Career Skills		Project report	During the 5th semester			
CA-CBT-800	**Module: Thesis / Seminar CBT**				**m**	**6**	**15**
CA-CBT-800-T	Thesis CBT	Thesis	Project/Thesis	15th of May			12
CA-CBT-800-S	Seminar CBT	Seminar	Presentation	During the semester			3
	Unit: Specialization CBT (at least one specialization module from Biotechnology)				**m**		**17.5**
Take a total 15 CP of specialization modules							
CA-S-CBT-802	**Specialization Module: Organometallic Chemistry**				**me**	**5**	**5**
CA-CBT-802	Organometallic Chemistry	Lecture	Oral examination	Examination period			
CA-S-CBT-804	**Specialization Module: Environmental Microbiology and Biotechnology**				**me**	**6**	**5**
CA-CBT-804	Environmental Microbiology and Biotechnology	Lecture	Written examination	Examination period			
CA-S-CBT-805	**Specialization Module: Biotechnology in Action**				**me**	**6**	**5**
CA-CBT-805	Biotechnology in Action	Excursion	Written examination	Examination period			
CA-S-CBT-803	**Specialization Module: Flourine in Organic Synthesis**				**me**	**6**	**2,5**
CA-CBT-803	Fluorine in Organic Synthesis	Lecture	Written examination	Examination period			
Specialization electives from MCCB and BCCB (see study program handbook for further information)					**me**	**5/6**	**5/7.5**

							15
	Unit: New Skills						**10**
Choose one of the two modules							
CTNS-NSK-05	**Module: Linear Model and Matrices**				**me**	**5**	**5**
CTNS-05	Linear Model and Matrices	Seminar (online)	Written examination	Examination period			
CTNS-NSK-06	**Module: Complex Problem Solving**				**me**	**5**	**5**
CTNS-06	Complex Problem Solving	Lecture (online)	Written examination	Examination period			
Choose one of the two modules							
CTNS-NSK-07	**Module: Argumentation, Data Visualization and Communication (perspective I)**				**me**	**5/6**	**5**
CTNS-07	Argumentation, Data Visualization and Communication (perspective I)	Lecture (online)	Written examination	Examination period		5	
CTNS-NSK-08	**Module: Argumentation, Data Visualization and Communication (perspective II)**				**me**	**5/6**	**5**
CTNS-08	Argumentation, Data Visualization and Communication (perspective II)	Lecture (online)	Written examination	Examination period		6	
Choose one of the two modules							
CTNS-NSK-09	**Module: Agency, Leadership, and Accountability**				**me**	**6**	**5**
CTNS-09	Agency, Leadership, and Accountability	Lecture (online)	Written examination	Examination period			
CTNS-CIP-10	**Module: Community Impact Project**				**me**	**5/6**	**5**
CTNS-10	Community Impact Project	Project	Project Assessment	During the Sememster			

Total CP	**180**

[1] Status (m = mandatory, me = mandatory elective)

[2] For a full listing of all CHOICE / CORE / CAREER / CONSTRUCTOR Track modules please consult the **CampusNet online catalogue** and /or the study program handbooks.

3 Module can be replaced with a CORE module from another study program in order to pursue a minor

[4] Module can be replaced with a CORE module from another study program in order to pursue a minor, but has to be taken in Year 3, replacing one specialization module

[5] German native speakers will have alternatives to the language courses (in the field of Humanities).

Figure 3: Study and Examination Plan

7 Chemistry and Biotechnology Modules

7.1 General and Inorganic Chemistry

<table>
<tr><td colspan="2">Module Name
General and Inorganic Chemistry</td><td>Module Code
CH-120</td><td>Level (type)
Year 1 (CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-120-A</td><td colspan="2">General and Inorganic Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-120-B</td><td colspan="2">General and Inorganic Chemistry Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Ulrich Kortz</td><td colspan="2">Program Affiliation

• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status

Mandatory for BCCB, CBT and CBT minor</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Tutorial (10 hours)
• Private study for the lecture (75 hours)
• Lab (26 hours)
• Private study for the lab (41.5 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, and fully understand the material before entering the laboratory and the risks associated with the daily goals.</td></tr>
<tr><td colspan="5">Content and Educational Aims

This module provides a theoretical introduction to general and inorganic chemistry covering the areas of chemical foundations, atoms, molecules, ions, stoichiometry, types of chemical reactions and solution stoichiometry, gases, atomic structure and periodicity, bonding (general concepts), covalent bonding (orbitals), chemical equilibrium, acids and bases, and acid-base equilibria. Furthermore, students learn the practical foundation principles of chemistry, including basic laboratory techniques, the qualitative analysis of anions and cations, strong/weak acids and bases, titrations, the solubility of salts, crystallization, redox reactions, gravimetric analysis, volumetric analysis, complex formation, and the synthesis of nanoparticles.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

By the end of the module, the student will be able to

1. Discuss basic concepts in general and inorganic chemistry
2. Recognize general properties of matter
3. Engage in fundamental concepts in measurements and moles
4. Identify basic types of chemical reactions
5. Perform stoichiometric calculations
6. Predict the general properties of gases
7. Understand elements and trends in the periodic table</td></tr>
</table>

8. Recognize and discuss basic concepts of chemical bonding
9. Predict the reactivity of elements and compounds
10. Find the locations and operating procedures of all safety equipment including the first aid kit, eyewash station, safety shower, fire extinguisher, and fire blanket
11. Use lab equipment and be familiar with key aspects of working in a laboratory environment
12. Correlate the theoretical concepts they learn in class and the actual experimental application of the various hypotheses, laws, techniques, materials, reactions, and instruments
13. Perform qualitative and quantitative determination of unknowns and know how to handle and analyze chemical compounds
14. Write proper Laboratory reports
15. Properly dispose of chemical waste

Indicative Literature

Zumdahl and Zumdahl, Chemistry, 9th edition, Brooks Cole, 2014;

Higson, Analytical Chemistry, Oxford University Press, 2005, or latest edition as appropriate, Parts 1 and 2;

Jeffrey et.al., Vogel's Textbook of Quantitative Chemical Analysis, Longman Group UK Limited, 5th edition, 1989;

Course Handout.

Usability and Relationship to Other Modules

- This module provides fundamental knowledge of chemistry and is a foundation for all other modules in CBT, BCCB, and MCCB

Examination Type: Module Component Examinations

Module Component 1: Lecture
Assessment Type: Written examination — Duration: 120 min
Weight: 67%

Scope: Intended learning outcomes of the lecture (1-9);

Module Component 2: Lab
Assessment Type: Laboratory reports — Length: 4-6 pages per report
Weight: 33%

Scope: Intended learning outcomes of the laboratory course (4, 5, 10-15)

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.2 Introduction to Biotechnology: Microbiology and Genetics

Module Name	**Module Code**	**Level (type)**	**CP**
Introduction to Biotechnology: Microbiology and Genetics	CH-121	Year 1 (CHOICE)	7.5

Module Components

Number	Name	Type	CP
CH-121-A	Introduction to Biotechnology	Lecture and tutorial	5
CH-121-B	Biotechnology Lab	Lab	2.5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
Prof. Dr. Elke Nevoigt	• Chemistry and Biotechnology (CBT)	Mandatory for CBT and minor CBT

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ General and Inorganic Chemistry ☒ General Biochemistry	☒ None	• General understanding of biomolecules and chemistry from the lectures General Biochemistry and General and Inorganic Chemistry

Frequency	**Forms of Learning and Teaching**
Annually (Spring)	• Lecture and tutorial (45 hours) • Lab (30 hours) • Private study (65 hours) • Exam preparation (47.5 hours)

Duration	**Workload**
1 semester	187.5 hours

Recommendations for Preparation

Read the manual for the laboratory course early and fully understand the material before entering the laboratory. Know the risks associated with the daily goals. Prepare MSDS sheets for the hazardous chemicals used in the lab course;

Content and Educational Aims

Biotechnology is the application of biology. More specifically, it is the application of cells or their ingredients (e.g., enzymes) for the development of products or processes for human use. The major goal of the module Introduction to Biotechnology is to provide the relevant fundamentals in microbiology (cell structure, nutrition and growth, diversity/evolution, genetics, molecular biology, and genetic engineering). The focus is on prokaryotic and eukaryotic model microorganisms. A brief introduction to metabolism, enzymes, and metabolic engineering is also included. The laboratory course makes students familiar with the work in a molecular biotechnology lab. Besides amplifying their basic laboratory skills (e.g., preparation of buffers and solutions including respective calculations, pH-adjustment, pipetting, and centrifugation), students practice fundamental methods for isolation and analysis of nucleic acids (genomic DNA extraction, RNA degradation, use of polymerase chain reaction, and restriction endonucleases for diagnostic purposes, agarose gel electrophoresis, visualization and quantification of nucleic acids) as well as of proteins (preparation of protein extracts from cells and quantification of proteins in solution).

Intended Learning Outcomes

By the end of the module, the student will be able to

1. recall the structure of eukaryotic and prokaryotic microbial cells relevant in industry;
2. discuss the structure and function of enzymes and their mode of action;
3. recognize concepts of microbial metabolism and growth;
4. identify levels at which the cellular metabolism can be regulated;
5. evaluate the perspectives of modern biotechnology;
6. employ hygiene and tidy laboratory work conditions;
7. apply the basics of genetics and fundamental processes of molecular biology;
8. acquire basic methods of recombinant DNA technology.

Indicative Literature

Madigan et. al., Brock Biology of Microorganisms, 15th edition, Pearson International, 2018;

Willey et al., Prescott's Microbiology, 11th edition, McGraw-Hill Education, 2019;

Brown, Gene Cloning and DNA Analysis, 7th edition, CreateSpace Independent Publishing Platform, 2018;

Clark and Pazdernik, Biotechnology: Applying the Genetic Revolution, Academic Cell, 2008;

Renneberg, Biotechnology for Beginners, 2nd edition, Academic Press, 2016.

Usability and Relationship to other Modules

- This module provides fundamentals in microbiology and molecular biology for students majoring in CBT
- It is the basis for the second-year modules Industrial Biotechnology and Bioprocess Engineering and for the specialization course Environmental Microbiology and Biotechnology

Examination Type: Module Component Examinations

Component 1: Lecture

Assessment Type: Written examination — Duration: 90 min, Weight: 66%

Scope: Intended learning outcomes of the lecture (1-5)

Component 2: Lab

Assessment Type: Written examination — Duration: 60 min, Weight: 33%

Scope: Intended learning outcomes of the laboratory course (6-8)

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.3 General Biochemistry

<table>
<tr><td colspan="3">Module Name
General Biochemistry</td><td>Module Code
CH-100</td><td>Level (type)
Year 1 (CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-100-A</td><td colspan="3">General Biochemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-100-B</td><td colspan="3">General Biochemistry Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Sebastian Springer DPhi</td><td colspan="3">Program Affiliation

• Biochemistry and Cell Biology (BCCB)</td><td colspan="2">Mandatory Status

Mandatory for BCCB, CBT, MCCB and minor BCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• High school level of chemistry, mathematics, physics and biology.</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Private study (90 hours)
• Safety instructions (1 hours)
• Reading lab manuals (6 hours)
• MSDS preparation (4 hours)
• Experimental work in the laboratory, including seminars (27.5 hours)
• Lab report writing (24 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
For this module, students should revise chemistry, mathematics, physics and biology at the high school level and ideally bring basic self-directed study skills at the high school level.
Students need to read the relevant chapters in the recommended textbooks and all course materials provided by the instructors (e.g., manuals for the laboratory course).
For participation in the laboratory course, students must have attended the general safety instructions, fire safety instructions and the mandatory safety instructions to the laboratory course (chemical and S1 safety). In addition, Material Safety Data Sheets have to be prepared.</td></tr>
<tr><td colspan="6">Content and Educational Aims

The CHOICE General Biochemistry Module aims at students with a good High School knowledge of chemistry, mathematics, physics, and biology as well as basic self-directed study skills at high school level. The module consists of two module components, one lecture and one laboratory course.
In the lecture, students gain solid first-year level understanding of biochemistry and learn how to apply and analyze basic concepts of biochemistry.
In the laboratory course, students develop their practical skills and acquire basic proficiency in the use of laboratory equipment. The experiments parallel the lecture content and allow students to apply methods testing for the chemical properties of biomolecules. Furthermore, students learn how to document, describe, and discuss experimental data.
In both module components, students also acquire meta-skills such as self-organization and teamwork.</td></tr>
</table>

Intended Learning Outcomes

By the end of this module, students will be able to

1. explain the chemical basics of the life sciences;
2. identify major classes of biological molecules;
3. describe the structure and function of proteins;
4. summarize the basic principles of anabolic and energy metabolism;
5. list the techniques and strategies in molecular life sciences;
6. relate gained knowledge and inductive reasoning to unknown topics in the molecular life sciences;
7. integrate new scientific information into the framework of the knowledge already obtained;
8. perform basic experiments in a Biosafety Level S1 Laboratory;
9. follow experimental procedures outlined in a laboratory manual;
10. relate an experimental setup to the aim of an experiment;
11. formulate expectations and hypotheses to be tested;
12. understand how different biomolecules can be analyzed by testing for their biochemical properties;
13. develop scientific writing skills regarding the depiction and description of experimental data as well as their interpretation in publication-style Laboratory reports;
14. correctly cite literature and know how to avoid plagiarism.

Indicative Literature

Becker et al., The World of the Cell. Benjamin/Cummings Series in the Life Sciences, latest edition.

Horton et al., Principles of Biochemistry, Prentice Hall, latest edition.

Alberts et al., Essential Cell Biology, Garland, latest edition.

General Introduction Manual and Lab Day Manuals provided by instructor

Usability and Relationship to other Modules

- The General Biochemistry Module provides an essential foundation for the study of BCCB.
- Introduction to Biotechnology

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination
Duration: 120 min
Weight: 67 %

Scope: All intended learning outcomes of the lecture (1-7)

Module Component 2: Lab

Assessment Type: Laboratory Reports
Duration: Approx. 10 pages per report
Weight: 33%

Scope: All intended learning outcomes of the laboratory course (8-14)

Module Achievement: To pass the module achievement, the average of six quizzes (one before each lab day) has to be 45% or higher.

Apart from acquiring practical skills, each participant further needs to demonstrate sufficient understanding of the theoretical background underlying each experiment. Only with sufficient knowledge, students may claim authorship on the written reports submitted.

Completion: To pass this module, the examination of each module component has to be passed with at least 45%

7.4 General Organic Chemistry

Module Name	Module Code	Level (type)	CP
General Organic Chemistry	CH-111	Year 1 (CHOICE)	7.5

Module Components

Number	Name	Type	CP
CH-111-A	General Organic Chemistry	Lecture	5
CH-111-B	General Organic Chemistry Lab	Lab	2.5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Thomas Nugent	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for BCCB, CBT and MCCB

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours) • Laboratory (25.5 hours) • Private for the study laboratory (37 hours)
☒ General and Inorganic Chemistry or General Medicinal Chemistry and Chemical Biology	☒ None	• Recognize organic functional groups • familiar with orbitals • exposed to the concept of equilibria • laboratory safety and awareness	**Duration** 1 semester	**Workload** 187.5 hours

Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering laboratory and the risks associated with the daily goals.

Content and Educational Aims

This module provides an introduction to Organic Chemistry and begins with general reactivity patterns and the supportive concepts of resonance, conjugation and aromaticity, which come from applying knowledge of orbitals. Carbanion, alcohol, and amine nucleophiles are introduced and this allows carbonyl additions resulting in: alcohol, acetal, imine, enamine, oxime, and 30harmacop formation to be discussed. The student is then exposed to the relationships between equilibria and rates of reaction to better understand mechanistic investigations. This is followed by an introduction to conformational analysis and stereochemistry which allow the transition states within the subsequent chapters on substitution, elimination, and addition reactions to be understood.

In a parallel manner, The student will learn that a chemistry laboratory is for exploring chemical reactions. However, before doing so we must demonstrate: safety aspects, common hazards, and the structure and content required for a laboratory report. After this, the essential techniques are shown for: setting up, monitoring (TLC, color change, etc.), and quenching (neutralize active chemicals) reactions. In parallel, the student will purify the products (chromatography, crystallization, separatory funnel extractions, etc.), and use basic methods to identify the products. While doing so, the student is exposed to the common equipment (rotary evaporator, melting point apparatus, etc.) within the laboratory. Reactions based on nucleophilic substitution, elimination, bromination to an alkene, electrophilic aromatic substitution, and the isolation of a natural product, characterize the experimental exposure within this laboratory.

Intended Learning Outcomes

By the end of the module, the student should be able to:

1. understand bond strength and angles using knowledge of orbitals;
2. recognize resonance effects versus inductive effects;
3. understand basic mechanisms and arrow pushing in organic chemistry;
4. differentiate some nucleophiles and electrophiles and their orbital connectivity to HOMO and LUMO concepts;
5. distinguish high and low energy conformations of molecules and recall their value for transition states;
6. identify basic symmetry elements, stereocenters, and be able to recognize the stereochemical outcome of selected reactions;
7. identify and recall specific structures and reactions discussed during class;
8. in addition to knowing the fire exit locations, students will be able to find the location and know the operating procedures of all safety equipment including the first aid kit, eyewash station, safety shower, fire extinguisher, and fire blanket in the laboratory;
9. handle and dispose of chemicals safely and show competence in locating and retrieving material safety data sheet (MSDS) information;
10. perform acid-base extractions;
11. monitor and quench organic reactions;
12. identify standard laboratory equipment;
13. set up reactions with assistance.

Indicative Literature

J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University Press, 2012.

Usability and Relationship to other Modules

- This module provides the foundation knowledge required for your 2nd year CORE modules

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type Written examination — Duration: 180 min; Weight: 67%

Scope: The first seven intended learning outcomes are connected to the lecture

Module Component 2: Lab

Assessment Type Laboratory reports — Length: Five to fifteen pages per report; Weight: 33%

Scope: The last six intended learning outcomes are connected to the laboratory

Completion: To pass this module, the examination of each module component has to be passed with at least 45%

7.5 Physical Chemistry

Module Name		Module Code	Level (type)	CP
Physical Chemistry		CO-440	Year 2 (CORE)	5
Module Components				
Number	Name		Type	CP
CO-440-A	Physical Chemistry		Lecture	5
Module Coordinator Prof. Dr. Detlef Gabel	**Program Affiliation** • Chemistry and Biotechnology (CBT)		**Mandatory Status** Mandatory for CBT and minor CBT Mandatory elective for MCCB and PHDS	
Entry Requirements Pre-requisites ☒ General and Inorganic Chemistry or ☒Modern Physics	Co-requisites ☒ None	Knowledge, Abilities, or Skills • None beyond formal prerequisites	**Frequency** Annually (Fall) **Duration** 2 semesters	**Forms of Learning and Teaching** • Lecture (45 hours) • Private study (45 hours) • Exam preparation (35 hours **Workload** 125 hours

Recommendations for Preparation

None

Content and Educational Aims

The module provides an introduction to Physical Chemistry and focusses on thermodynamics, kinetics, intermolecular forces, surfaces, and electrochemistry. It also provides an introduction to quantum chemistry. This knowledge is essential to understand when chemical reactions can take place and how fast they can occur, and how molecules interact with each other and the solvent.

Intended Learning Outcomes

By the end of the module, the student will be able to

1. use the gas laws to predict the behavior of perfect and real gases;
2. differentiate between enthalpy, entropy, and Gibbs energy;
3. correlate Gibbs energy with equilibrium constants;
4. derive the velocities of reactions of zero, first, and the second order;
5. derive the velocities of enzyme reactions and coupled reactions;
6. explain and apply the concept of activation energy;
7. calculate the velocity of reactions as a function of temperature;
8. recognize phase transitions from measurable properties;
9. explain and apply fundamentals in electrochemistry;
10. explain how given molecules and their functional groups can interact with each other and their surroundings;
11. recognize the different approaches to quantum chemical calculations;
12. use an electronic lab book and share their own results with others through it;
13. derive the fundamental equations of importance in physical chemistry;
14. demonstrate presentation skills;

Indicative Literature

Atkins and de Paula, Elements of Physical Chemistry, 7th edition. Oxford: Oxford University Press, 2017.

Usability and Relationship to other Modules

- Pre/corequisite for the Inorganic and Physical Chemistry lab

Examination Type: Module Examination

Assessment Component 1: Written examination

Duration: 120 min.
Weight: 75%

Scope: Intended learning outcomes of the module (1-12)

Assessment Component 2: Presentation

Duration 15 min
Weight 25%

Scope: Intended learning outcomes of the module (13-14)

Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.6 Industrial Biotechnology

<table>
<tr><td colspan="2">Module Name
Industrial Biotechnology</td><td>Module Code
CO-441</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-441-A</td><td colspan="2">Industrial Biotechnology</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Elke Nevoigt</td><td colspan="2">Program Affiliation

• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status

Mandatory for CBT and minor CBT

Mandatory Elective for BCCB</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ Introduction to Biotechnology or ☒ Cell Biology
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • None beyond formal prerequisites</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (45 hours)
• Private study (45 hours)
• Exam preparation (35 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation

None.</td></tr>
<tr><td colspan="5">Content and Educational Aims

This module provides insight into how biotechnology impacts chemical production. The replacement of both chemical catalysts by enzymes and cells and of fossil resources by renewable raw materials are two aspects that are increasingly pushed by the chemical industry in order to achieve a more sustainable production of bulk and fine chemicals, building blocks for chemical industry as well as food ingredients, bioplastics, and biofuels. Using a number of commercially successful examples as well as current R&D efforts of chemical industry, students will be introduced to the advantages and practice of implementing cells or enzymes for the production of industrially relevant products. Moreover, the module describes the utilization of biomass and biomass waste streams as feedstock for the production of the above mentioned compounds.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

By the end of the module, the student will be able to

1. evaluate the use of renewable as opposed to fossil resources as raw materials for chemical production;
2. explain the impact of using enzymes and cells in the chemical and pharmaceutical industry;
3. evaluate the value and applications of industrial enzymes;
4. express the concept of a cell factory;
5. list important commercial products made by microorganisms;
6. assess the limitations of natural organisms for chemical production;
7. evaluate the feasibility of a bio-based process compared to its chemical counterpart;
8. identify possibilities to modify the characteristics of an enzyme
9. sketch the basic concept of metabolic engineering;</td></tr>
</table>

Indicative Literature

Glazer and Nikaido, Microbial Biotechnology: Fundamentals of Applied Microbiology,2nd edition, Cambridge University Press, 2007;
Lehninger, Principles of Biochemistry: International Edition, WH Freeman, 2017;
Ratledge and Kristiansen, Basic Biotechnology, 3rd edition, Cambridge University Press, 2006;
Schmidt, Pocket Guide for Biotechnology and Genetic Engineering, 2003;
Madigan et. al., Brock Biology of Microorganisms, 15th edition, Pearson International, 2018;
Willey et al., Prescott's Microbiology, 11th edition, McGraw-Hill Education, 2019;

Usability and Relationship to other Modules

- The module Industrial Biotechnology is complementary to the Advanced Biotechnology Lab and synergistic to the Specialization course Environmental Microbiology and Biotechnology;

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%.

7.7 Advanced Inorganic Chemistry

<table>
<tr><td colspan="3">Module Name
Advanced Inorganic Chemistry</td><td>Module Code
CO-442</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-442-A</td><td colspan="3">Advanced Inorganic Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Ulrich Kortz</td><td colspan="3">Program Affiliation

• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status

Mandatory for CBT and minor CBT</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ General and Inorganic Chemistry
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • None beyond formal prerequisites</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Tutorial (10 hours)
• Private study for lecture (80 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
</table>

Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, and fully understand the material before entering the laboratory and the risks associated with the daily goals.

Content and Educational Aims

This module introduces advanced concepts of inorganic chemistry, such as Molecular Structure and Bonding (VB theory, MO theory, and semiconductors), Symmetry and Group Theory, Structures of Solids (metals, and ionic solids), d-metal Complexes (structure and symmetry, bonding and electronic structure, and reactions of complexes), the Electronic Spectra of Complexes (electronic spectra of atoms vs complexes, and the bonding and spectra of M-M bonded compounds).

Intended Learning Outcomes

By the end of the module, the student will be able to

1. discuss advanced concepts of inorganic and organometallic chemistry;
2. master various topics such as the synthesis of inorganic compounds, bonding, structure, etc.;
3. explain coordination compounds, their nomenclature and isomerism;
4. determine the electronic structure of d-metal complexes and explain their properties (correlate between electronic structure and properties);
5. explain the elements in the periodic table and the periodic properties of these elements.
6. predict the geometries of inorganic compounds;
7. determine the structure and symmetry of molecules and correlate between symmetry and properties;
8. categorize the point group of molecules and identify character tables;

Indicative Literature

Atkins et. al, Shriver and Atkins' Inorganic Chemistry, 5th edition, Oxford University Press, 2009;

Huheey et al., Inorganic Chemistry, 4th edition., Addison Wesley, 1997;

Miessler et al., Inorganic Chemistry, 4rd edition, Pearson, 2003;

Vincent, Molecular Symmetry and Group Theory, Wiley, 2011.

Usability and Relationship to other Modules

- This module provides advanced knowledge and deeper understanding of inorganic chemistry, and exposes students to various analytical instruments used beyond inorganic chemistry and chemistry in general;

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 minutes
Weight: 100%

Module achievement: students have to give a presentation (10-15 min) during the lecture in order to be eligible to participate in the written examination. The presentation is not numerically graded (pass/fail).

Scope: All intended learning outcomes of the module;

Completion: To pass this module, the examination has to be passed with at least 45%.

7.8 Advanced Organic Chemistry

Module Name			Module Code	Level (type)	CP
Advanced Organic Chemistry			CO-423	Year 2 (CORE)	5
Module Components					
Number	Name			Type	CP
CO-423-A	Advanced Organic Chemistry			Lecture	5
Module Coordinator Prof. Dr. Thomas Nugent	**Program Affiliation** • Medicinal Chemistry and Chemical Biology (MCCB)			**Mandatory Status** Mandatory for CBT and MCCB	
Entry Requirements Pre-requisites ☒ General Organic Chemistry	 Co-requisites ☒ Adv. Organic and Analytical Laboratory	 Knowledge, Abilities, or Skills • Transition state analysis • Selectivity in synthesis • Expanded reaction knowledge	**Frequency** Annually (Fall) **Duration** 1 semester	**Forms of Learning and Teaching** • Lecture (35 hours) • Tutorial (10 hours) • Private study (80 hours) **Workload** 125 hours	
Recommendations for Preparation Review concepts from General Organic Chemistry, early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering class, attend voluntary tutorials					
Content and Educational Aims This module builds on the General Organic Chemistry module by broadening reaction type exposure and evaluating transition states to appreciate product selectivity during synthesis. To allow these possibilities, the concepts of regiochemistry, chemoselectivity, diastereoselectivity, and enantioselectivity are addressed. This in turn allows synthetic pathways for more complicated molecules to be proposed and evaluated. The student will additionally know the general reactivity patterns of carbocations, radicals, and anions and in some instances know when to apply that knowledge. These combined conceptual points will be expressed during discussions of aromatic substitution, Michael reactions (conjugate addition), aldol, Claisen, and Diels-Alder reactions.					
Intended Learning Outcomes By the end of this module component, students should be able to 1. understand the value of the order of reactions within multi-step synthesis. 2. design three step reaction sequences. 3. appreciate retrosynthetic approaches to synthesize selected molecules. 4. discern chemoselective and regioselective challenges. 5. recognize the stereochemical outcomes of selected reactions. 6. evaluate and apply transition state analysis to selected reactions. 7. complete some reaction mechanisms. 8. will know common carbonyl group reaction transformations. 9. identify and recall specific structures and reactions discussed during class					
Indicative Literature J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University, 2012.					

Usability and Relationship to other Modules

- Completion of this module allows the student to understand the common concepts, reactions, and reactivity patterns of organic chemistry. It enhances the learning outcomes for CORE modules Medicinal Chemistry, Chemical Biology, and Pharmaceutical Chemistry, but is not a pre-requisite for those modules.

Examination Type: Module Examination

Assessment Type Written examination

Duration: 180 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

7.9 Scientific Software and Databases

Module Name Scientific Software and Databases		**Module Code** CO-443	**Level (type)** Year 2 (CORE)	**CP** 5
Module Components				
Number	Name		Type	CP
CO-443-A	Scientific Software and Databases		Lecture	5
Module Coordinator Prof. Dr. Detlef Gabel	**Program Affiliation** • Chemistry and Biotechnology (CBT)		**Mandatory Status** Mandatory elective for CBT, BCCB and MCCB	
Entry Requirements Pre-requisites: ☒ None Co-requisites: ☒ None Knowledge, Abilities, or Skills: • None		**Frequency** Annually (Spring)	**Forms of Learning and Teaching** • Lecture (20 hours) • Seminar (15 hours) • Homework and self-study (50 hours) • Preparation of term paper (45 hours)	
		Duration 1 semester	**Workload** 125 hours	
Recommendations for Preparation First-year modules in General Chemistry, Organic Chemistry, Biochemistry, and Biotechnology				
Content and Educational Aims The students will be familiarized with software to visualize scientific information in chemistry and life sciences. They will be familiarized with the sources used to draw the relevant scientific information, and the retrieval of primary sources of data. They will be familiarized with software to present results, and with software to numerically evaluate data.				

Intended Learning Outcomes

By the end of this module, students should be able to

1. use software to write reports and scientific papers;
2. use software to evaluate and handle numerical data;
3. use software to present data graphically;
4. use Entrez as a source of information on the life sciences;
5. use software to draw chemical structures;
6. use SciFinder to find information on research subjects, chemical structures and substructures, reactions to and from given structures, and patents;
7. use the Cambridge Data System to retrieve data on crystal structures;
8. use software to visualize data for small molecules;
9. use PDB to retrieve and three-dimensionally visualize data on protein structures and interactions;
10. use software to visualize protein structures and the interaction of small molecules with proteins;
11. use GenBank to retrieve information on gene sequences and the similarities between genes;
12. use metabolic data banks to retrieve information on metabolic pathways;
13. use data banks to obtain information about clinical trials;
14. use data banks to obtain data on toxicity and the side effects of drugs;
15. retrieve the primary sources of information of such data.

Indicative Literature

Handout provided by instructor.

Usability and Relationship to other Modules

- Module can be replaced with a CORE module from another study program in CBT in order to pursue a minor, but has to be taken in Year 3, replacing one specialization module

Examination Type: Module Examination

Assessment Type: Portfolio (Active in-class participation, Assignments [individual/group]) Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

7.10 Advanced Organic and Analytical Chemistry Lab

Module Name	Module Code	Level (type)	CP
Advanced Organic and Analytical Chemistry Lab	CO-424	Year 2 (CORE)	5

Module Components

Number	Name	Type	CP
CO-424-A	Advanced Organic Chemistry Lab	Lab	2.5
CO-424-B	Analytical Chemistry Lab	Lab	2.5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Thomas Nugent	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for CBT and MCCB

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Fall)	• Lab (51 hours) • Private study lab (74 hours)
☒ None	☒Analytical Methods ☒Advanced Organic Chemistry	• Laboratory safety	**Duration** 1 semester	**Workload** 125 hours

Recommendations for Preparation

Fully understand the material before entering laboratory and the risks associated with the daily goals.

Content and Educational Aims

A chemical laboratory is a place for exploration, and the second semester of organic laboratory places you squarely in that environment. Here you will set up your own reactions and be taught why an atmosphere of nitrogen, free of moisture, is required when using more reactive reagents. You will also expand your techniques, e.g., employing distillation, and be exposed to important instrumentation, e.g., nuclear magnetic resonance, for product identification. Importantly, you will begin to appreciate the entire process of designing and then performing a reaction. Starting from your reaction table displaying the required stoichiometry and weight or volume of the starting materials, to the order and timing of compound additions, to the isolation of your pure product whose structure you can support via chromatographic and/or spectroscopic evidence. On completing this laboratory you will have an appreciation for the manipulation of common organic functional groups and by extension, some of the challenges of synthesizing a pharmaceutical drug.
Analytical chemistry is an important applied area of chemistry. This part of the laboratory module will introduce students an introduction to experimental analytical chemistry. The use of spectrometers and chromatographic equipment will be demonstrated to students followed by set experiments to be performed independently by the students. A set of six dedicated experiments on UV/Vis-, NMR-, and IR spectroscopy, mass spectrometry, gas chromatography and HPLC will be performed by the students in small groups (2-3 students) under supervision. Subsequently students are asked to record their data, interpret their experimental findings, estimate errors, and report them.

Intended Learning Outcomes

By the end of this module component, students will be able to:

1. independently set-up, monitor, and quench organic reactions;
2. inform yourself about chemical hazards;
3. dispose of chemicals properly;
4. identify and use standard organic laboratory equipment;
5. suggest purification methods for organic compounds;
6. familiar with more advanced organic laboratory techniques;
7. obtain a ^{1}H NMR spectrum with assistance;

8. illustrate knowledge on instrumental methods including spectroscopic and separation techniques;
9. explain and understand the physical principles behind spectroscopic and separation techniques;
10. measure and analyze real samples;
11. apply knowledge on instrumental techniques to solve qualitative and quantitative experimental analytical problems;
12. interpret spectroscopic data and deduce chemical structures from that data;
13. compare spectroscopic data and predict spectral properties from chemical structures;
14. calculate quantitative values from analytical results;
15. prepare scientific reports and critical analysis on the experimental findings of analytical results.

Indicative Literature

J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University, 2012.

Usability and Relationship to other Modules

- These laboratories are critical for establishing the skills required to perform the thesis research and the introduced techniques and instruments provide the hands-on knowledge that complement the theoretical content learned in the CORE year modules.

Examination Type: Module Examination

Assessment Type: Laboratory reports

Length: 3-15 pages
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

7.11 Bioprocess Engineering

Module Name	Module Code	Level (type)	CP
Bioprocess Engineering	CO-444	Year 2 (CORE)	5

Module Components

Number	Name	Type	CP
CO-444-A	Bioprocess Engineering	Lecture and tutorial	5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Detlef Gabel	• Chemistry and Biotechnology (CBT)	Mandatory for CBT

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ Introduction to Biotechnology ☒ Industrial Biotechnology	☒ None	• None beyond formal prerequisites

Frequency	Forms of Learning and Teaching
Annually (Spring)	• Lecture and tutorial (45 hours) • Private study (45 hours) • Exam preparation (35 hours)

Duration	Workload
1 semester	125 hours

Recommendations for Preparation

Content and Educational Aims

Biotechnological advances in the laboratory require appropriate strategies for implementation in industrial practice. One main pre-requisite for its exploitation is the ability to efficiently scale up any processes involved for final product delivery to the market. Process biotechnology is concerned with the design, dovetailing, performance evaluation, and final implementation of unit operations. Examples are fermentation, solid-liquid separation, extraction and leaching, adsorption and chromatography. Every production scheme has to be validated in terms of product quality and processing costs. Software packages may be employed to illustrate processing alternatives.

Intended Learning Outcomes

By the end of this module, students should be able to

1. describe the concept of bioeconomy;
2. explain the impact of biorefining in the chemical industry;
3. recognize how process biotechnology works;
4. explain heat transfer and mass transfer phenomena;
5. evaluate the feasibility of process schemes;
6. discuss the potential of biorefineries for sustainable chemical production;
7. bridge chemistry with biology and technology;
8. apply simple modelling tools to understand the performance of biotechnological processes;

Indicative Literature

Doran, Bioprocess Engineering Principles,2nd edition, Academic Press, 2012;

Day et. al., Bioseparations Science and Engineering, Oxford University Press, 2002.

Usability and Relationship to other Modules	
Examination Type: Module Examination Assessment Type: Written examination Scope: All intended learning outcomes of the module Completion: To pass this module, the examination has to be passed with at least 45%.	Duration: 120 min. Weight: 100%

7.12 Advanced Biotechnology Lab

Module Name Advanced Biotechnology Lab			Module Code CO-445	Level (type) Year 2 (CORE)	CP 5
Module Components					
Number	Name			Type	CP
CO-445-A	Advanced Biotechnology Lab			Lab	5
Module Coordinator Dr. Mathias Klein	**Program Affiliation** • Chemistry and Biotechnology (CBT)			**Mandatory Status** Mandatory for CBT	
Entry Requirements Pre-requisites ☒ none	Co-requisites ☒Industrial Biotechnology	Knowledge, Abilities, or Skills • None beyond formal prerequisites	**Frequency** Annually (Fall)	**Forms of Learning and Teaching** • Lab and seminars (60 hours) • Private study (35 hours) • Exam preparation (30 hours)	
			Duration 2 weeks (intersession)	**Workload** 125 hours	

Recommendations for Preparation

Read manual for the laboratory course early on and fully understand the material before entering the laboratory. Know the risks associated with the daily goals. Prepare MSDS sheets for the hazardous chemicals used in the lab course.

Content and Educational Aims

A breakthrough in modern biotechnology is the recombinant production of proteins (e.g., pharmaproteins as well as industrial and diagnostic enzymes). The major advantages of heterologous protein production over the isolation of these proteins from natural sources are i) significantly higher yields, ii) safer production, iii) higher purity of the protein and iv) the possibility of producing protein variants with improved characteristics. Today, about 50% of all approved pharmaproteins are produced in microbial hosts. The full pipeline requires the cloning of the respective protein-encoding sequence into a suitable expression vector, the transformation of the microbial production host, the expression of the relevant protein, the optimization of process conditions and downstream processing. The final steps include quality control and theformulation of the target product;
The first part of this course aims at familiarizing future biotechnologists with fundamental techniques for recombinant protein expression in the microbial host E. coli. The second part will include training in state-of-the-art methods for bioprocess engineering and downstream bioprocessing. The students will follow the path from cloning a protein-coding sequence through protein expression and product recovery.

Intended Learning Outcomes

By the end of the module, the student will be able to

1. employ methods for the cultivation of microorganisms on solid and in liquid media;
2. apply tidy and sterile working techniques according to good microbiological techniques (GMT);
3. apply and explain basic molecular biology techniques (plasmid isolation and analysis, agarose gel electrophoresis, restriction-ligation cloning, and PCR) as well as the transformation of the bacterium Escherichia coli;

4. apply and evaluate methods to generate protein variants by random mutagenesis and site directed mutagenesis;
5. discuss concepts of generating and analyzing mutant protein libraries;
6. apply different biomass separation and concentration methods (centrifugation, ultra-centrifugation filtration, and ultrafiltration);
7. apply different cell disruption methods;
8. differentiate and apply several purification methods (affinity, ion exchange, hydrophobic interaction, size-exclusion, and reversed phase chromatography);
9. operate product (biomolecule) characterization and quantification (SDS Polyacrylamide Gel Electrophoresis (SDS PAGE), Western Blot, and spectrophotometric protein determination assays);
10. appraise the importance and application of biomolecules in our daily lives;

Indicative Literature

Arnold, Directed Evolution: Creating Biocatalysts for the Future, In Chemical Engineering Science 51 (23): 5091-5102l, 1996;

Tsien, The Green Fluorescent Protein. Annual Reviews of Biochemistry 67:509-544, 1998;

Course handout provided by the instructor.

Usability and Relationship to other Modules

- The Advanced Biotechnology Lab is complementary to the lectures Industrial Biotechnology and Bioprocess Engineering;

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%.

7.13 Inorganic and Physical Chemistry Lab

Module Name		**Module Code**	**Level (type)**	**CP**
Inorganic and Physical Chemistry Lab		CO-446	Year 2 (CORE)	5
Module Components				
Number	Name		Type	CP
CO-446-A	Inorganic Chemistry Lab		Lab	2.5
CO-446-B	Physical Chemistry Lab		Lab	2.5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
Prof. Dr. Ulrich Kortz	• Chemistry and Biotechnology (CBT)	Mandatory for CBT

Entry Requirements			**Frequency**	**Forms of Learning and Teaching**
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Lab (51 hours) • Private study lab (74 hours)
☒ General and Inorganic Chemistry	☒ None	• None beyond formal prerequisites	**Duration** 1 semester	**Workload** 125 hours

Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, and fully understand the material before entering the laboratory and the risks associated with the daily goals.

Content and Educational Aims

In its Advanced Inorganic Chemistry Lab, this module allows students to apply advanced concepts of inorganic chemistry, such as Molecular Structure and Bonding (VB theory, MO theory, and semiconductors), Symmetry and Group Theory, Structures of Solids (metals and ionic solids), d-metal Complexes (structure and symmetry, bonding and electronic structure, and the reactions of complexes), the Electronic Spectra of Complexes (electronic spectra of atoms versus complexes and the bonding and spectra of M-M bonded compounds) by performing experiments designed to prove the abovementioned concepts. It also provides students with the opportunity to perform experiments such as the synthesis, separation, purification, and characterization of inorganic main-group and transition metal compounds. Quantitative analysis (gravimetric and spectrometric). Kinetics of inorganic reactions. Instrumentation used: FT-IR, UV-vis, AA, TGA, XRD, and NMR;

The physical chemistry laboratory provides an overview of the function of typical laboratory instruments used for physical chemistry characterization. First, students gain hands-on experience to create solutions, and second to decide which instrument is best suited and to use typical instruments such as UV-vis, fluorimenter, Zetapotential, particle sizer, pH meter, conductometer, Osmometer, etc;

Furthermore, students learn to use a lab book (electronic lab book I-labber), as well as learning to describe the goal of an experiment, document the results, and perform simple statistical analysis.

Intended Learning Outcomes

By the end of the module, the student will be able to

1. synthesize and characterize inorganic and organometallic complexes;
2. correlate between the theoretical concepts introduced in class and the actual experimental application of the various hypotheses, laws, techniques, materials, reactions, and instruments;
3. use analytical instruments such as a Uv-vis spectrophotometer, infrared spectrophotometer, thermogravimetric analyzer, atomic absorption spectrophotometer, x-ray diffractrometer, and nuclear magnetic resonance spectrometer;
4. plot and analyze data obtained from an analytical experiment and correlate it with the theory;
5. communicate the results of scientific experiments in technical graphics, and written reports;
6. prepare electrolyte solutions, using the pH meter, and conductometry;
7. perform osmotic pressure measurement;
8. perform viscosity measurements;
9. perform spectroscopic measurement (UV-vis, and fluorescence emission);
10. perform particle sizing;
11. describe the outline of an experiment, and provide a protocol of the experiment together with a statistical analysis;
12. document an experiment in a lab book (or electronic lab book-i-labber);

Indicative Literature

A manual/handout will be provided by the instructor;

Atkins and de Paula, Elements of Physical Chemistry, 7th edition. Oxford: Oxford University Press, 2017.

Usability and Relationship to other Modules

Examination Type: Module Component Examinations

Module Component 1: Lab 1

Assessment Type: Laboratory reports

Length: 4-8 pages per assignment

Weight: 50%

Scope: Intended learning outcomes of Inorganic Chemistry Lab (ILOs 1-5)

Module Component 2: Lab 2

Assessment Type: Project assessment (lab performance)

Weight: 50%

Scope: Intended learning outcomes of Physical Chemistry Lab (ILOs 4-12)

Module achievements: 66% of the assignments passed.

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.14 Biotechnology in Action

Module Name		Module Code	Level (type)	CP
Biotechnology in Action		CA-CBT-805	Year 3 (Specialization)	5
Module Components				
Number	Name		Type	CP
CA-CBT-805	Biotechnology in Action		Excursion	5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Detlef Gabel	• Chemistry and Biotechnology (CBT)	Mandatory elective CBT and MCCB

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Excursion (30 hours) • Lecture (17.5 hours) • Private Study including preparation of a presentation (77.5 hours)
☒ Industrial Biotechnology	☒ none			
			Duration	**Workload**
			1 Semester	125 hours

Recommendations for Preparation

Content and Educational Aims

The module communicates basic knowledge in the use of biotechnology for industry and other purposes. Real processes in the pharmaceutical industry, the chemical industry and the food industry, among others, are subject to study and are presented either through a field trip or through lectures by industry representatives. The students will understand the sources of microorganisms and enzymes used in such processes, understand the disposal of side products and waste, and estimate the energetic balances of such large-scale processes.
The industry lectures and field trips are complemented by lectures in which advanced aspects of process design are discussed, such as the principles of conceptual design, block, process or P&I flow diagrams, technical-economic and ecological assessments of bioprocesses.

Intended Learning Outcomes

Upon completion of this module, students will be able to:

1. identify sources for microorganisms in large-scale processes
2. understand the problems caused by waste and side products of large-scale processes
3. understand how recycling or upcycling can be used for waste and side products
4. identify the energy needed for such processes, and how the off-heat can be used for the processes
5. understand the supply chains in such processes

Literature / Reading List

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100 %

Module achievement: An oral presentation is a module achievement and a prerequisite for participation in the exam.

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

7.15 Flourine in Organic Synthesis

Module Name		Module Code	Level (type)	CP
Flourine in Organic Synthesis		CA-CBT-803	Year 3 (Specialization)	2.5
Module Components				
Number	Name		Type	CP
CA-CBT-803	Flourine in Organic Synthesis		Lecture	2.5
Module Coordinator Prof. Dr. Detlef Gabel	**Program Affiliation** • Chemistry and Biotechnology (CBT)		**Mandatory Status** Mandatory elective CBT	
Entry Requirements		**Frequency** Spring	**Forms of Learning and Teaching** • Lecture (17.5 hours) • Private Study (45 hours)	
Pre-requisites ☒ Advanced Organic Chemistry	Co-requisites ☒ none	Knowledge, Abilities, or Skills		
		Duration 1 Semester	**Workload** 62.5 hours	

Recommendations for Preparation

Content and Educational Aims

The module communicates basic knowledge in synthetic approaches for fluorinated organic compounds. In the last few decades, fluorine and fluorinated compounds mostly human made have attracted significant attention and are greatly involved in our daily life, having extremely beneficial aspects, but also several environmental drawbacks. The unique properties of the fluorine atom and carbon-fluorine bonds is the reason that fluorinated organic chemicals are nowadays a major, dynamically developing research topic in both academia and industry laboratories. New synthetic methods and methodologies are the driving forces of advancements in organofluorine chemistry. For modern technologies, medicine, new drugs, photonics, energy storage through batteries, surfactants, fire emulsions, high-performance polymers amongst others, fluorinated materials are indispensable.

Intended Learning Outcomes

Upon completion of this module, students will be able to:

1. understand different synthetic routes for fluorinated compounds and propose new approaches
2. analyze and apply the unique properties of organofluorine compounds
3. evaluate the ecological impact
4. identify fluorochemicals, e.g., by 19F NMR spectroscopy
5. comprehend applications of organofluorine compounds as polymers, materials, pharmaceuticals and agrochemicals

Literature / Reading List

A. Haupt, Organic and Inorganic Fluorine Chemistry: Methods and Applications, 1st ed. De Gruyter 2021, ISBN: 978-3110659290

K. J. Szabó, N. Selander, Organofluorine Chemistry, Synthesis, Modeling, Applications, 1st ed, Wiley-VCH 2021, Weinheim, ISBN: 978-3527347117

P. Kirsch, Modern Organofluorine Chemistry, 2nd ed, Wiley-VCH 2013, Weinheim, ISBN 978-3-527-33166-6

I. Ojima Ed., Frontiers of Organofluorine Chemistry, WSPC (Europe), 2019, ISBN 978-1786347329

J. Hu, T. Umemoto (Eds.), Fluorination, Springer, 2020, ISBN: 978-9811038976

D. Cahard, Jun-An Ma, Emerging Fluorinated Motifs: Synthesis, Properties and Applications, 2 Vol., 1st ed, Wiley-VCH 2020, Weinheim, ISBN 978-3527346813

K. Seppelt (Ed.), The Curious World of Fluorinated Molecules, Elsevier, 2020, ISBN: 978-0128198742.

H. Groult, F. Leroux, A. Tressaud (Eds.), Modern Synthesis Processes and Reactivity of Fluorinated Compounds, Elsevier, 2016, ISBN: 978-0128037409.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration: 120 min
Weight: 100 %

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

7.16 Medicinal Chemistry

Module Name	Module Code	Level (type)	CP
Medicinal Chemistry	CO-420	Year 2 (CORE)	5

Module Components

Number	Name	Type	CP
CO-420-A	Medicinal Chemistry	Lecture	5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Detlef Gabel	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for MCCB and minor MCCB Mandatory elective for CBT

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ General Biochemistry ☒ General Organic Chemistry	☒ None	• None beyond formal prerequisites

Frequency	Forms of Learning and Teaching
Annually (Fall)	• Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)

Duration	Workload
1 semester	125 hours

Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering class, and attend voluntary tutorials

Content and Educational Aims

This module provides an insight into the design of drugs, their interactions with targets, and the role of selected targets in selected diseases. It will introduce the concepts of isosteres and bioisosteres. The physical basis of interactions between drugs and targets will be explained. Methods for determining the site and binding strength of drugs to targets will be presented. The optimization of a lead compound to a drug will be detailed. Assay systems for drug optimizations will be presented. The path of drugs from the design to clinical use will be followed. The concept of 54harmacophore will be presented. Stereochemical aspects of drug design will be discussed. Rules for drug design and fragment-based drug design will be explained. The ADME concept will be introduced. LD50 and ED50, as well as dose-response curves, will be presented. Structure-activity relationships will be discussed.

Intended Learning Outcomes

By the end of the module, the student will be able to

1. propose a series of isosteres and bioisosteres for common functional groups;
2. understand the principles of testing affinities of drugs to targets;
3. analyze the interaction potential of drugs with their targets;
4. sketch the path of a drug from lead structure to clinical trial;
5. differentiate between conventional and fragment-based drug design;
6. propose ways to identify targets on which specific molecules act
7. estimate the changes in structure and its effect on ADME;
8. extract information about structure-activity relationships from a given research paper on drug design;
9. explain the testing methods employed in the paper;
10. explain changes in interaction potentials for given modifications of a compound;
11. explain the role of the drug in the disease and identify the role of the target.

Indicative Literature

- B.E. Blass. Basic Principles of Drug Discovery and Development, 2015, ISBN 978-0124115088.

- G.L. Patrick. An Introduction to Medicinal Chemistry, 2013, ISBN 978-0199697397

Usability and Relationship to other Modules

- This module is of central importance because it provides the first medicinal chemistry foundation that is then expanded on by other second year (CORE) modules, e.g., Phsyical Chemistry and Molecular Modelling, Chemical Biology, Pharmaceutical Chemistry, and High Throughput Screening.

Examination Type: Module Examination

Assessment Component 1: Written examination — Duration: 75 min, Weight: 67%

Scope: Items 1 to 7 of the above learning outcomes of the module.

Assessment Component 2: Presentation — Duration 20 minutes, Weight 33%

Scope: Items 8-11 of the above learning outcomes of the module

Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.17 Environmental Microbiology and Biotechnology

Module Name			**Module Code**	**Level (type)**	**CP**
Environmental Microbiology and Biotechnology			CA-S-CBT-804	Year 3 (Specialization)	5
Module Components					
Number	Name			Type	CP
CA-S-CBT-804	Environmental Microbiology and Biotechnology			Lecture	5
Module Coordinator Dr. Boran Kartal	**Program Affiliation** • Chemistry and Biotechnology (CBT)			**Mandatory Status** Mandatory elective for BCCB and CBT	
Entry Requirements Pre-requisites ☒ General and Inorganic Chemistry ☒ General Biochemistry ☒ Introduction to Biotechnology or ☒ Microbiology (for BCCB students)	Co-requisites ☒ none	Knowledge, Abilities, or Skills • Basic knowledge of Microbiology, Molecular Biology, Biotechnology	**Frequency** Annually (Spring) **Duration** 1 semester	**Forms of Learning and Teaching** • Lecture and presentations (45 hours) • Private study (45 hours) • Exam preparation (35 hours) **Workload** 125 Hours	
Recommendations for Preparation Taking the CORE Modules Industrial Biotechnology (CBT) and Microbiology (BCCB) is helpful. Recall the contents of General Biochemistry Module.					
Content and Educational Aims The topics of the Environmental Microbiology and Biotechnology module are the elemental cycles (Carbon, Nitrogen, Sulfur and Iron) that take place in nature. In these "cycles" microorganisms, the most abundant living things on earth, convert different forms of elements to one and other [e.g. methane oxidizing bacteria oxidize methane (CH_4) to carbon dioxide (CO_2)]. In this module, the metabolic pathways that the microorganisms use to convert their substrates and the methodology to detect these microorganisms are described to the students in detail. Furthermore, the application of these microorganisms in wastewater treatment will be discussed.					

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. Explain the biogeochemical processes within Carbon, Nitrogen, Sulphur and Iron cycles.
2. Name and classify the microorganisms responsible for the conversion of elements at different redox states (e.g. NO_3^- reduction to N_2 or CH_4 oxidation to CO_2)
3. Describe the key types of energy metabolism of microorganisms (e.g. denitrification, photosynthesis, methanogenesis, fermentation, ammonium and methane oxidation, etc.).
4. Identify the impact of human activities on the natural cycles.
5. Classify the biodiversity of prokaryotes and the evolutionary relations between ecologically relevant species including the current theories and concepts concerning microbial evolution.
6. Compare and contrast conventional and advanced techniques that are used to detect microbiological activities in nature.
7. Summarize the most up-to-date developments in the field of microbiology.
8. Critically read and discuss scientific literature.

Indicative Literature

Madigan et al, Brock Biology of Microorganisms, 15th edition, Pearson, 2018;
Nelson and Cox, Lehninger, Principles of Biochemistry, 7th edition, W.H. Freeman, Macmillan Learning, 2017

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min.
Weight: 100%

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%.

7.18 Organometallic Chemistry

Module Name	Module Code	Level (type)	CP
Organometallic Chemistry	CA-S-CBT-802	Year 3 (Specialization)	5

Module Components

Number	Name	Type	CP
CA-CBT-802	Organometallic Chemistry	Lecture	5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Detlef Gabel	• Chemistry and Biotechnology (CBT)	Mandatory elective for CBT and MCCB

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Fall)	• Lecture (35 hours) • Private study (75 hours) • Exam preparation (15 hours)
☒ General and Inorganic Chemistry ☒ General Organic Chemistry	☒ None	• None beyond formal prerequisites	**Duration** 1 semester	**Workload** 125 hours

Recommendations for Preparation

- Organometallic Chemistry, Gary O. Spessard, G. L. Miessler, Oxford University Press, 3rd Revised Edition, 2016;
- The Organometallic Chemistry of the Transition Metals, R. H. Crabtree, Wiley, 6th Edition, 2014;
- Bioorganometallic Chemistry Applications in Drug Discovery, Biocatalysis, and Imaging, Gérard Jaouen, Michèle Salmain, Wiley-VCH Verlag GmbH, 2015;
- Organometallics, Albrecht Salzer, Christoph Elschenbroich, Wiley-VCH Verlag GmbH, 3rd Revised Edition, 2003.

Content and Educational Aims

This course deals with all aspects of organometallic chemistry. The main topics are synthesis, bonding and structures, stability, reactions and the use of Main Group Metal and Transition Metal Organyls, electron deficient systems, s- and p-bonding, sandwich complexes, heterogenous and homogenous catalysis, industrially important processes, for example, Fischer-Tropsch-Reactions, Wacker Oxidation, Hydroformylation, Reppe-Synthesis, and coupling reactions. The role of bioorganometallics in biochemistry, medicinal chemistry, and cellular imaging will be highlighted.

Intended Learning Outcomes

By the end of the module, the student will be able to know about

1. classification and electronegativity considerations;
2. fundamentals of structure and bonding;
3. energy, polarity, and reactivity of the M-C bond;
4. NMR characterization of organometallics;
5. Main-Group organometallics (lithium, magnesium, aluminium, and tin);
6. transition metal organyls: concept of s-donor, s-donor/p-acceptor, s, and p -donor/p-acceptor ligands;
7. transition metal organyls: concept of metal-carbene and carbyne complexes;
8. isolobal concept;
9. metathesis and polymerization reactions and industrial processes;

10. concept of C-C bond formation (coupling reactions);
11. use of organometallics in medicine (enzyme inhibitors);
12. concept of metalloproteins;
13. concept of organometallic bioprobes for cellular imaging;

Indicative Literature

Gary et al., Organometallic Chemistry, Oxford University Press, 3rd Revised Edition, 2016;

Jaouen et. al., Bioorganometallic Chemistry Applications in Drug Discovery, Biocatalysis, and Imaging, Wiley-VCH Verlag GmbH, 2015;

Salzer and Elschenbroich, Organometallics, Wiley-VCH Verlag, 3rd Revised Edition, 2003.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Oral examination

Duration: 40 minutes
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

7.19 Advanced Organic Synthesis

Module Name			Module Code	Level (type)	CP
Advanced Organic Synthesis			CA-S-MCCB-801	Year 3 (Specialization)	5
Module Components					
Number	Name			Type	CP
CA-MCCB-801	Advanced Organic Synthesis			Lecture	5
Module Coordinator Prof. Dr. Thomas Nugent	**Program Affiliation** • Medicinal Chemistry and Chemical Biology (MCCB)			**Mandatory Status** Mandatory elective for CBT and MCCB	
Entry Requirements Pre-requisites ☒ Advanced Organic Chemistry	Co-requisites ☒ None	Knowledge, Abilities, or Skills • Broad organic chemistry concepts	**Frequency** Annually (Fall)	**Forms of Learning and Teaching** • Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)	
			Duration 1 semester	**Workload** 125 hours	

Recommendations for Preparation

Review the concepts within Advanced Organic Chemistry

Content and Educational Aims

Building on your basic knowledge of functional group transformations and stereochemistry, strategies for the synthesis of complex building blocks, natural products, or pharmaceutical drugs will be discussed from the primary literature. In this context, you will learn the importance of the order and type of transformation (retrosynthetic analysis) required for brevity in synthesis. Critical reaction steps, examples of which could be, enantioselective hydrogenation, biaryl coupling, aldol reactions, etc., will be discussed at length to define current transition state knowledge and substrate limitations. In doing so, you will learn the how and why of organic reaction product selectivity. In a parallel manner, functional group compatibility, pKa, the use of modern reagents, radical clock chemistry, the nuances of chemo-, regio-, diastereo-, and enantiocontrol through the use of proximal functional groups vs enantioselective catalysis, etc. will be discussed when and where appropriate.

Indicative Literature

J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University, 2012.
Solomon and Fryhle, Organic Chemistry, Edition 8, 21.12 Special Topic G: Transition Metal Organometallic Compounds, p 1055-1065.

O. Reiser Chem. Rev. 1999, 99, 1191-1223.

S. Mukherjee, J. W. Yang, S. Hoffmann, B. List Chem. Rev. 2007, 107, 5471-5569.

C. D. Johnson Acc. Chem. Res. 1993, 26, 476-482.

K. Gilmore and I. V. Alabugin Chem. Rev. 2011, 111, 6513–6556.

R. Noyori, T. Ohkuma Angew. Chem. Int. Ed. 2001, 40, 40-73.

J. Paradies Coordination Chem. Rev. 2019, 380, 170–183.

J. Reed, T. Hudlicky Acc. Chem. Res. 2015, 48, 674-687.

Usability and Relationship to other Modules

- This module is for students who continue to be curious and want to extends their studies in organic synthesis and may be considering graduate level education in Medicinal Chemistry or Organic Chemistry.

Examination Type: Module Examination

Assessment Type: Oral examination

Duration: 40 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

7.20 Internship / Startup and Career Skills

Module Name		**Module Code**	**Level (type)**	**CP**
Internship / Startup and Career Skills		CA-INT-900	Year 3 (CAREER)	15
Module Components				
Number	Name		Type	CP
CA-INT-900-0	Internship		Internship	15
Module Coordinator Clémentine Senicourt & Dr. Tanja Woebs (SCS Organization); SPC / Faculty Startup Coordinator (Academic responsibility)	**Program Affiliation** • CAREER module for undergraduate study programs		**Mandatory Status** Mandatory for all undergraduate study programs except IEM	
Entry Requirements Pre-requisites ☒ at least 15 CP from CORE modules in the major	Co-requisites ☒ None	Knowledge, Abilities, or Skills • Information provided on CSC pages (see below) • Major specific knowledge and skills	**Frequency** Annually (Spring/Fall) **Duration** 1 semester	**Forms of Learning and Teaching** • Internship/Start-up • Internship event • Seminars, info-sessions, workshops and career events • Self-study, readings, online tutorials **Workload** 375 Hours consisting of: • Internship (308 hours) • Workshops (33 hours) • Internship Event (2 hours) • Self-study (32 hours)

Recommendations for Preparation

- Please see the section "Knowledge Center" at JobTeaser Career Center for information on Career Skills seminar and workshop offers and for online tutorials on the job market preparation and the application process. For more information, please see https://constructor.university/student-life/career-services
- Participating in the internship events of earlier classes

Content and Educational Aims

The aims of the internship module are reflection, application, orientation, and development: for students to reflect on their interests, knowledge, skills, their role in society, the relevance of their major subject to society, to apply these skills and this knowledge in real life whilst getting practical experience, to find a professional orientation, and to develop their personality and in their career. This module supports the programs' aims of preparing students for gainful, qualified employment and the development of their personality.

The full-time internship must be related to the students' major area of study and extends lasts a minimum of two consecutive months, normally scheduled just before the 5th semester, with the internship event and submission of the internship report in the 5th semester. Upon approval by the SPC and SCS, the internship may take place at other times, such as before teaching starts in the 3rd semester or after teaching finishes in the 6th semester. The Study Program Coordinator or their faculty delegate approves the intended internship a priori by reviewing the tasks in either the Internship Contract or Internship Confirmation from the respective internship institution or company. Further regulations as set out in the Policies for Bachelor Studies apply.

Students will be gradually prepared for the internship in semesters 1 to 4 through a series of mandatory information sessions, seminars, and career events.
The purpose of the Career Services Information Sessions is to provide all students with basic facts about the job market in general, and especially in Germany and the EU, and services provided by the Student Career Support.

In the Career Skills Seminars, students will learn how to engage in the internship/job search, how to create a competitive application (CV, Cover Letter, etc.), and how to successfully conduct themselves at job interviews and/or assessment centers. In addition to these mandatory sections, students can customize their skill set regarding application challenges and their intended career path in elective seminars.
Finally, during the Career Events organized by the Student Career Support (e.g. the annual Constructor Career Fair and single employer events on and off campus), students will have the opportunity to apply their acquired job market skills in an actual internship/job search situation and to gain their desired internship in a high-quality environment and with excellent employers.

As an alternative to the full-time internship, students can apply for the StartUp Option. Following the same schedule as the full-time internship, the StartUp Option allows students who are particularly interested in founding their own company to focus on the development of their business plan over a period of two consecutive months. Participation in the StartUp Option depends on a successful presentation of the student's initial StartUp idea. This presentation will be held at the beginning of the 4th semester. A jury of faculty members will judge the student's potential to realize their idea and approve the participation of the students. The StartUp Option is supervised by the Faculty StartUp Coordinator. At the end of StartUp Option, students submit their business plan. Further regulations as outlined in the Policies for Bachelor Studies apply.

The concluding Internship Event will be conducted within each study program (or a cluster of related study programs) and will formally conclude the module by providing students the opportunity to present on their internships and reflect on the lessons learned within their major area of study. The purpose of this event is not only to self-reflect on the whole internship process, but also to create a professional network within the academic community, especially by entering the Alumni Network after graduation. It is recommended that all three classes (years) of the same major are present at this event to enable networking between older and younger students and to create an educational environment for younger students to observe the "lessons learned" from the diverse internships of their elder fellow students.

Intended Learning Outcomes

By the end of this module, students should be able to

1. describe the scope and the functions of the employment market and personal career development;
2. apply professional, personal, and career-related skills for the modern labor market, including self-organization, initiative and responsibility, communication, intercultural sensitivity, team and leadership skills, etc.;
3. independently manage their own career orientation processes by identifying personal interests, selecting appropriate internship locations or start-up opportunities, conducting interviews, succeeding at pitches or assessment centers, negotiating related employment, managing their funding or support conditions (such as salary, contract, funding, supplies, work space, etc.);
4. apply specialist skills and knowledge acquired during their studies to solve problems in a professional environment and reflect on their relevance in employment and society;
5. justify professional decisions based on theoretical knowledge and academic methods;
6. reflect on their professional conduct in the context of the expectations of and consequences for employers and their society;
7. reflect on and set their own targets for the further development of their knowledge, skills, interests, and values;
8. establish and expand their contacts with potential employers or business partners, and possibly other students and alumni, to build their own professional network to create employment opportunities in the future;
9. discuss observations and reflections in a professional network.

Indicative Literature Not specified
Usability and Relationship to other Modules • This module applies skills and knowledge acquired in previous modules to a professional environment and provides an opportunity to reflect on their relevance in employment and society. It may lead to thesis topics.
Examination Type: Module Examination Assessment Type: Project Report Length: approx. 3.500 words Scope: All intended learning outcomes Weight: 100%

7.21 Bachelor Thesis and Seminar

Module Name			Module Code	Level (type)	CP
Bachelor Thesis and Seminar CBT			CA-CBT-800	Year 3 (CAREER)	15
Module Components					
Number	Name			Type	CP
CA-CBT-800-T	Thesis CBT			Thesis	12
CA-CBT-800-S	Thesis Seminar CBT			Seminar	3
Module Coordinator Study Program Chair	**Program Affiliation** • All undergraduate programs			**Mandatory Status** Mandatory for all undergraduate programs	
Entry Requirements Pre-requisites ☒ Students must have taken and successfully passed a total of at least 30 CP from advanced modules, and of those, at least 20 CP from advanced modules in the major.	Co-requisites ☒ None	Knowledge, Abilities, or Skills • comprehensive knowledge of the subject and deeper insight into the chosen topic; • ability to plan and undertake work independently; • skills to identify and critically review literature.	**Frequency** Annually (Spring) **Duration** 14-week lecture period	**Forms of Learning and Teaching** • Self-study/lab work (350 hours) • Seminars (25 hours) **Workload** 375 hours	

Recommendations for Preparation

- Identify an area or a topic of interest and discuss this with your prospective supervisor in a timely manner.
- Create a research proposal including a research plan to ensure timely submission.
- Ensure you possess all required technical research skills or are able to acquire them on time.
- Review the University's Code of Academic Integrity and Guidelines to Ensure Good Academic Practice.

Content and Educational Aims

This module is a mandatory graduation requirement for all undergraduate students to demonstrate their ability to address a problem from their respective major subject independently using academic/scientific methods within a set time frame. Although supervised, this module requires students to be able to work independently and systematically and set their own goals in exchange for the opportunity to explore a topic that excites and interests them personally and that a faculty member is interested in supervising. Within this module, students apply their acquired knowledge about their major discipline and their learned skills and methods for conducting research, ranging from the identification of suitable (short-term) research projects, preparatory literature searches, the realization of discipline-specific research, and the documentation, discussion, interpretation, and communication of research results.

This module consists of two components, an independent thesis and an accompanying seminar. The thesis component must be supervised by a Constructor University faculty member and requires short-term research work, the results of which must be documented in a comprehensive written thesis including an introduction, a justification of the methods, results, a discussion of the results, and a conclusion. The seminar provides students with the opportunity to practice their ability to present, discuss, and justify their and other students' approaches, methods, and results at various stages of their research in order to improve their academic writing, receive and reflect on formative feedback, and therefore grow personally and professionally.

Intended Learning Outcomes

On completion of this module, students should be able to

1. independently plan and organize advanced learning processes;
2. design and implement appropriate research methods, taking full account of the range of alternative techniques and approaches;
3. collect, assess, and interpret relevant information;
4. draw scientifically-founded conclusions that consider social, scientific, and ethical factors;
5. apply their knowledge and understanding to a context of their choice;
6. develop, formulate, and advance solutions to problems and debates within their subject area, and defend these through argument;
7. discuss information, ideas, problems, and solutions with specialists and non-specialists.
8. evaluate situations and make decisions based on ethical considerations, and adhere to and defend ethical, scientific, and professional standards

Usability and Relationship to other Modules

- This module builds on all previous modules in the undergraduate program. Students apply the knowledge, skills, and competencies they have acquired and practiced during their studies, including research methods and their ability to acquire additional skills independently as and if required.

Examination Type: Module Component Examinations

Module Component 1: Thesis
Assessment type: Thesis
Scope: All intended learning outcomes, mainly 1-6.

Length: approx. 6.000 – 8.000 words (15 – 25 pages), excluding front and back matter.
Weight: 80%

Module Component 2: Seminar
Assessment type: Presentation

Duration: approx. 15 to 30 minutes
Weight: 20%

Scope: The presentation focuses mainly on ILOs 6 and 7, but by nature of these ILOs it also touches on the others.

Module Achievement: Attendance of online lecture series on ethical topics.

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

Two separate assessments are justified by the size of this module and the fact that the justification of solutions to problems and arguments (ILO 6) and discussion (ILO 7) should at least have verbal elements. The weights of the types of assessments are commensurate with the sizes of the respective module components.

8 Constructor Track Modules

8.1 Methods Modules

8.1.1 Mathematical Concepts for the Sciences

Module Name		**Module Code**	**Level (type)**	**CP**
Mathematical Concepts for the Sciences		CTMS-MAT-07	Year 1 (Methods)	5
Module Components				
Number	Name		Type	CP
CTMS-07	Mathematical Concepts for the Sciences		Lecture	5
Module Coordinator(s)	**Program Affiliation**		**Mandatory Status**	
Dr. Keivan Mallahi Karai	• CONSTRUCTOR Track Area		Mandatory for BCCB, CBT, ESSMER and MCCB	
Entry Requirements		**Frequency**	**Forms of Learning and Teaching**	
Pre-requisites: ☒ None	Co-requisites: ☒ None; Knowledge, Abilities, or Skills: • none	Annually (Fall)	• Lectures (35 hours) • Private study (90 hours)	
		Duration	**Workload**	
		1 semester	125 hours	
Recommendations for Preparation				
Review basic mathematical concepts and tools.				

Content and Educational Aims

In this module, students develop and strengthen quantitative problem-solving skills that are important in the natural sciences. Hands-on exercises and group work are integrated in the lectures to maximize feedback between the students and the instructor. The module starts with a review of elementary mathematical concepts such as functions and their graphs, units and dimensions, and series and convergence. Vectors and matrices are introduced using linear equations, and then motivated further in the context of basic analytical geometry. An extended section on calculus proceeds from basic differentiation and integration to the solution of differential equations, always guided by applications in the natural sciences. The module is concluded by a data-oriented introduction to descriptive statistics and basic statistical modeling applied to laboratory measurements and observations of natural systems.

Intended Learning Outcomes

By the end of this module, students will be able to

1. identify important types of quantitative problems in the natural sciences;
2. select and use key solution strategies, methods, and tools;
3. explain and apply linear algebra concepts and techniques;
4. analyze models and observations of natural systems using derivatives and integrals;
5. classify differential equations, find equilibria, and apply standard solution methods;
6. process data by means of descriptive statistics and basic regression techniques.

Indicative Literature

E. N. Bodine, S. Lenhart, and L. J. Gross (2014). Mathematics for the Life Sciences. Princeton: Princeton University Press.

D. Cherney, T. Denton, A. Waldron (2013, June). Linear Algebra. Retrieved from: https://www.math.ucdavis.edu/~linear/.

K.F. Riley, M.P. Hobson, and S.J. Bence (2002). Mathematical methods for physics and engineering, Cambridge: Cambridge University Press.

M. Corral. Vector Calculus (2008). Retrieved from: http://www.mecmath.net/calc3book.pdf.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of this module.

Completion: To pass this module, the examination has to be passed with at least 45%.

8.1.2 Physics for the Natural Sciences

Module Name			Module Code	Level (type)	CP
Physics for the Natural Sciences			**CTMS-SCI-17**	Year 1 (Methods)	5
Module Components					
Number	Name			Type	CP
CTMS-17	Physics for the Natural Sciences			Lecture	5
Module Coordinator Prof. Dr. Jürgen Fritz	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory for BCCB, CBT, and MCCB	
Entry Requirements			**Frequency** Annually (Spring)	**Forms of Learning and Teaching** • Lecture (35 hours) • Private study including homework (90 hours)	
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills			
☒ None	☒ None	• High school math • Basic high school physics	**Duration** 1 semester	**Workload** 125 hours	

Recommendations for Preparation

Review high school math (especially calculus, geometry and vector analysis) and high school physics (basics of motion, forces and energy). Level and content follows the along standard textbooks for calculus-based first year general university physics, such as Young & Freedman: University Physics; Halliday, Resnick & Walker: Fundamentals of Physics; or others.

Content and Educational Aims

Physics is the most fundamental of all natural sciences and serves as a basis for other sciences and engineering disciplines. This module introduces non-physics majors to the basic principles, facts, and experimental evidence from physics, as it is needed especially for the life sciences, geosciences, and chemistry.
Emphasis is placed on general principles and general mathematical concepts for a basic understanding of physical phenomena. Basic mathematics (geometry, calculus, vector analysis) is used to develop a quantitative and scientific description of physical phenomena. A voluntary tutorial is offered to discuss homework or topics of interest in more detail.
The lecture provides an overview of the basic fields of physics such as mechanics (motion, force, energy, momentum, oscillations, fluid mechanics), thermodynamics (temperature, heat, 1st law, ideal gas and kinetic gas theory, thermodynamic processes, entropy), electromagnetism (charge, electric field, potential, current, magnetic field, induction), optics (oscillations, waves, sound, reflection and refraction, lenses and optical instruments, interference and diffraction), and modern physics (particle-wave duality, atoms and electrons, absorption and emission, spin, NMR, ionizing radiation, radioactivity).

Intended Learning Outcomes

By the end of the module, students will be able to:

1. recall the basic facts and experimental evidence in mechanics, thermodynamics, electromagnetism, optics and modern physics;
2. use the basic concepts of motion, force, energy, oscillations, heat, and light to describe natural and technical phenomena;

3. apply basic problem-solving strategies from physics to test the plausibility of ideas or arguments, such as reducing different natural phenomena to their underlying physical principles, or using analogies, approximations, estimates or extreme cases;
4. apply basic calculus, geometry, and vector analysis for a quantitative description of physical systems.

Indicative Literature

Young & Freedman, University Physics, with Modern Physics, Pearsson, latest edition.

Halliday, Resnick, Walker, Fundamentals of Physics, Extended Version, Wiley, latest edition.

Zinke-Allmang et al., Physics for the Life Sciences, Nelson Education, latest edition.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

8.1.3 Analytical Methods

Module Name			Module Code	Level (type)	CP
Analytical Methods			**CTMS-SCI-16**	Year 2 (Methods)	5

Module Components			
Number	Name	Type	CP
CTMS-16	Analytical Methods	Lecture	5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
Prof. Dr. Nikolai Kuhnert	• CONSTRUCTOR Track Area	Mandatory for MCCB and CBT Mandatory elective for BCCB

Entry Requirements			**Frequency**	**Forms of Learning and Teaching**
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Fall)	• Lecture (35 hours) • Tutorial (10 hours) • Private study (80 hours)
☒ None	☒ None	• Basic knowledge in Life Sciences	**Duration**	**Workload**
			1 semester	125 hours

Recommendations for Preparation

Students should have a sound background knowledge in general chemistry and MCCB as well as organic chemistry acquired by attending the respective CHOICE courses. They should have understood the basic principles of chemical bonding and chemical structures as well as the basic concepts of quantification and experimental measurement.

Content and Educational Aims

Analytical science is an important applied area of all chemical and life sciences. Analytical science deals with the separation, identification, and quantification of any chemical compound. It therefore provides an interface between the traditional areas of organic, inorganic, and physical chemistry with life sciences and all other areas of science requiring the identification and quantification of chemical compounds. It provides the methods and toolbox for all experimental sciences. Analytical chemistry provides the tools for all areas of experimental chemistry and a good foundation of analytical techniques is not only expected of any chemist but also for scientists at the interface to the life sciences. The course will give an introduction to analytical chemistry with selected applications. This will include an introduction to analytical terms and definitions, basic statistic treatment of experimental data, qualitative and quantitative analysis and instrumental analysis with an emphasis on spectroscopic techniques such as UV/Vis, NMR, mass spectrometry, IR and Raman spectroscopy, and fluorimetry. Furthermore, separation techniques such as HPLC and GC will be introduced. A series of lectures covering application in drug analysis, clinical chemistry, forensics, and toxicology will complement the course.

Intended Learning Outcomes

By the end of this module, students will be able to

1. illustrate knowledge of instrumental methods including spectroscopic techniques and separation techniques;
2. explain and understand physical principles behind spectroscopic techniques and separation techniques and apply them to practically-orientated issues;
3. apply knowledge of instrumental techniques to solve qualitative and quantitative analytical problems;
4. interpret spectroscopic data and deduce chemical structures from these data;
5. compare spectroscopic data and predict spectral properties from chemical structures;

6. calculate quantitative values from analytical results;
7. plan analytical experiments to solve chemical problems;
8. calculate and estimate errors in analytical procedures by applying statistical methods;
9. test scientific hypotheses;
10. prepare scientific reports and critical analysis on experimental findings of analytical results.

Indicative Literature

Clayden, Greeves, Warren, Organic Chemistry, 2nd Edition, 2012 (ISBN 978-0-19-927029-3).

P.W. Atkins, Physical Chemistry 9th edition, 2006 (ISBN 9780198700722).

R. Kellner, J. Mermet, M. Otto, M. Valcarel, M. Widmer, Analytical Chemistry: A Modern Approach to Analytical Science, 2nd ed., 2004(ISBN: 978-3-527-30590-2).

Usability and Relationship to other Modules

- It complements the Analytical Chemistry laboratory course and provides the experimental tool box for all fields of chemistry and the associated life sciences.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 180 min
Weight: 100%

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%.

8.1.4 Plant Metabolism and Natural Products

Module Name		Module Code	Level (type)	CP
Plant Metabolism and Natural Products		CTMS-SCI-18	Year 2 (Methods)	5
Module Components				
Number	Name		Type	CP
CTMS-18	Plant Metabolism and Natural Products		Lecture	5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Matthias Ullrich	• CONSTRUCTOR Track Area	Mandatory for BCCB, MCCB Mandatory elective for CBT

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Lecture (35 hours) • Private study (90 hours)
☒ None	☒ None	• Comprehensive high school knowledge of chemistry, mathematics, physics, biochemistry, and cell biology	**Duration** 1 semester	**Workload** 125 hours

Recommendations for Preparation

Students should have a sound background knowledge in chemistry, mathematics, physics, biochemistry and cell biology.

Read the chapter “Plant Form and Function” (Joanne Chory) in the recommended textbook of Neil A. Campbell and Jane B. Reece, BIOLOGY, Benjamin Cummings, Pearson Education, current edition.

Content and Educational Aims

Understanding general principles of biochemical processes in living cells requires a rigorous and robust knowledge of nature’s ways and capacities to form and use primary and secondary metabolites from inorganic materials via the autotrophic (producer) mode of algae and plants. This module introduces methods to assess and understand the breath-taking diversity of plant biochemical and cellular processes, plant metabolism, as well as plant-borne substances including their purposes and functions. An array of compounds produced by plants that are relevant to human health and nutrition will be introduced. This is done by demonstrating natural functions of biomolecules in plant metabolism or during regulation of biochemical processes. Methods to asses and quantify photosynthesis and the Calvin cycle will be introduced, as will be those needed to understand the phytohormone-based language of plants. State-of-the-art methods on how to analyze the fascinating types of interactions with other organisms is explained. Plant genetic engineering is introduced, and its methodology are explained in detail. Modern aspects of agriculture, food production, and the application of natural products in medicine will complete this methods survey of plant metabolism and natural products.

Intended Learning Outcomes

By the end of this module, students will be able to

1. apply knowledge of biochemical and cellular processes to understand principles in the world of plants and algae;
2. illustrate a plant's basic metabolic and biochemical features of plants;
3. describe plant cells and plant tissue characteristics;
4. explain how photosynthesis and the Calvin cycle enable autotrophic life;
5. delineate how plants interact with their biotic and abiotic environment;
6. explain the basic principles of Environmental Biochemistry;
7. classify plant hormones, their roles, and the importance of their homeostasis;
8. interpret the bioactivity potential of natural products;
9. outline processes in plant biochemistry and plant genetics;
10. describe natural product biosynthesis;
11. illustrate how plants use basic building blocks to create complex structures;
12. relate biological activities of natural products with their use for medicinal purposes;
13. transfer the acquired knowledge to novel natural products;
14. explain the importance of functional groups in natural products for bioactivity.

Indicative Literature

Urry et. al., Campell Biology, Pearson, latest edition.

Buchanan, Biochemistry and Molecular Biology of Plants, Wiley, latest edition.

Madigan et.al., Brock Biology of Microorganisms, latest edition.

Usability and Relationship to other Modules

- It complements the non-photosynthesis learning components of BCCB's general education. It furthermore provides essential background knowledge for medicinal chemistry, chemical biology, chemistry, and biotechnology.
- For CBT major students: the module can be replaced with a CORE module from another study program to pursue a minor.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%.

8.2 New Skills

8.2.1 Logic (perspective I)

Module Name			Module Code	Level (type)	CP
Logic (perspective I)			CTNS-NSK-01	Year 2 (New Skills)	2.5
Module Components					
Number	Name			Type	CP
CTNS-01	Logic (perspective I)			Lecture (online)	2.5
Module Coordinator Jules Coleman	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective for all UG students (one perspective must be chosen)	
Entry Requirements			**Frequency** Annually (Fall)	**Forms of Learning and Teaching** • Online lecture (17.5h) • Private study (45h)	
Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills	**Duration** 1 semester	**Workload** 62.5 hours	
Recommendations for Preparation					
Content and Educational Aims					

Suppose a friend asks you to help solve a complicated problem? Where do you begin? Arguably, the first and most difficult task you face is to figure out what the heart of the problem actually is. In doing that you will look for structural similarities between the problem posed and other problems that arise in different fields that others may have addressed successfully. Those similarities may point you to a pathway for resolving the problem you have been asked to solve. But it is not enough to look for structural similarities. Sometimes relying on similarities may even be misleading. Once you've settled tentatively on what you take to be the heart of the matter, you will naturally look for materials, whether evidence or arguments, that you believe is relevant to its potential solution. But the evidence you investigate of course depends on your formulation of the problem, and your formulation of the problem likely depends on the tools you have available – including potential sources of evidence and argumentation. You cannot ignore this interactivity, but you can't allow yourself to be hamstrung entirely by it. But there is more. The problem itself may be too big to be manageable all at once, so you will have to explore whether it can be broken into manageable parts and if the information you have bears on all or only some of those parts. And later you will face the problem of whether the solutions to the particular sub problems can be put together coherently to solve the entire problem taken as a whole.

What you are doing is what we call engaging in computational thinking. There are several elements of computational thinking illustrated above. These include: Decomposition (breaking the larger problem down into smaller ones); Pattern recognition (identifying structural similarities); Abstraction (ignoring irrelevant particulars of the problem): and Creating Algorithms), problem-solving formulas.

But even more basic to what you are doing is the process of drawing inferences from the material you have. After all, how else are you going to create a problem-solving formula, if you draw incorrect inferences about what information has shown and what, if anything follows logically from it. What you must do is apply the rules of logic to the information to draw inferences that are warranted.

We distinguish between informal and formal systems of logic, both of which are designed to indicate fallacies as well as warranted inferences. If I argue for a conclusion by appealing to my physical ability to coerce you, I prove nothing about the truth of what I claim. If anything, by doing so I display my lack of confidence in my argument. Or if the best I can do is berate you for your skepticism, I have done little more than offer an ad hominem instead of an argument. Our focus will be on formal systems of logic, since they are at the heart of both scientific argumentation and computer developed algorithms. There are in fact many different kinds of logic and all figure to varying degrees in scientific inquiry. There are inductive types of logic, which purport to formalize the relationship between premises that if true offer evidence on behalf of a conclusion and the conclusion and are represented as claims about the extent to which the conclusion is confirmed by the premises. There are deductive types of logic, which introduce a different relationship between premise and conclusion. These variations of logic consist in rules that if followed entail that if the premises are true then the conclusion too must be true.

There are also modal types of logic which are applied specifically to the concepts of necessity and possibility, and thus to the relationship among sentences that include either or both those terms. And there is also what are called deontic logic, a modification of logic that purport to show that there are rules of inference that allow us to infer what we ought to do from facts about the circumstances in which we find ourselves. In the natural and social sciences most of the emphasis has been placed on inductive logic, whereas in math it is placed on deductive logic, and in modern physics there is an increasing interest in the concepts of possibility and necessity and thus in modal logic. The humanities, especially normative discussions in philosophy and literature are the province of deontic logic.

This module will also take students through the central aspects of computational thinking, as it is related to logic; it will introduce the central concepts in each, their relationship to one another and begin to provide the conceptual apparatus and practical skills for scientific inquiry and research.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students will be able to

6. apply the various principles of logic and expand them to computational thinking.
7. understand the way in which logical processes in humans and in computers are similar and different at the same time.
8. apply the basic rules of first-order deductive logic and employ them rules in the context of creating a scientific or social scientific study and argument.
9. employ those rules in the context of creating a scientific or social scientific study and argument.

Indicative Literature

Frege, Gottlob (1879), Begriffsschrift, eine der arithmetischen nachgebildete Formelsprache des reinen Denkens [Translation: A Formal Language for Pure Thought Modeled on that of Arithmetic],Halle an der Salle: Verlag von Louis Nebert.

Gödel, Kurt (1986), Russels mathematische Logik. In: Alfred North Whitehead, Bertrand Russell: Principia Mathematica. Vorwort, S. V–XXXIV. Suhrkamp.

Leeds, Stephen. "George Boolos and Richard Jeffrey. Computability and logic. Cambridge University Press, New York and London1974, x+ 262 pp." The Journal of Symbolic Logic 42.4 (1977): 585-586.

Kubica, Jeremy. Computational fairy tales. Jeremy Kubica, 2012.

McCarthy, Timothy. "Richard Jeffrey. Formal logic: Its scope and limits. of XXXVIII 646. McGraw-Hill Book Company, New York etc. 1981, xvi+ 198 pp." The Journal of Symbolic Logic 49.4 (1984): 1408-1409.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination Duration: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.3 Logic (perspective II)

Module Name		Module Code	Level (type)	CP
Logic (perspective II)		CTNS-NSK-02	Year 2 (New Skills)	2.5

Module Components

Number	Name	Type	CP
CTNS-02	Logic (perspective II)	Lecture (online)	2.5

Module Coordinator	Program Affiliation	Mandatory Status
NN	• CONSTRUCTOR Track Area	Mandatory elective for all UG students (one perspective must be chosen)

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ none	☒ none	

Frequency	Forms of Learning and Teaching
Annually (Fall)	• Online lecture (17.5h) • Private study (45h)

Duration	Workload
1 semester	62.5 hours

Recommendations for Preparation

Content and Educational Aims

The focus of this module is on formal systems of logic, since they are at the heart of both scientific argumentation and computer developed algorithms. There are in fact many kinds of logic and all figure to varying degrees in scientific inquiry. There are inductive types of logic, which purport to formalize the relationship between premises that if true offer evidence on behalf of a conclusion and the conclusion and are represented as claims about the extent to which the conclusion is confirmed by the premises. There are deductive types of logic, which introduce a different relationship between premise and conclusion. These variations of logic consist in rules that if followed entail that if the premises are true then the conclusion too must be true.

This module introduces logics that go beyond traditional deductive propositional logic and predicate logic and as such it is aimed at students who are already familiar with basics of traditional formal logic. The aim of the module is to provide an overview of alternative logics and to develop a sensitivity that there are many different logics that can provide effective tools for solving problems in specific application domains.

The module first reviews the principles of a traditional logic and then introduces many-valued logics that distinguish more than two truth values, for example true, false, and unknown. Fuzzy logic extends traditional logic by replacing truth values with real numbers in the range 0 to 1 that are expressing how strong the believe into a proposition is. Modal logics introduce modal operators expressing whether a proposition is necessary or possible. Temporal logics deal with propositions that are qualified by time. Once can view temporal logics as a form of modal logics where propositions are qualified by time constraints. Interval temporal logic provides a way to reason about time intervals in which propositions are true.

The module will also investigate the application of logic frameworks to specific classes of problems. For example, a special subset of predicate logic, based on so-called Horn clauses, forms the basis of logic programming languages such as Prolog. Description logics, which are usually decidable logics, are used to model relationships and they have applications in the semantic web, which enables search engines to reason about resources present on the Internet.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students will be able to

1. apply the various principles of logic
2. explain practical relevance of non-standard logic
3. describe how many-valued logic extends basic predicate logic
4. apply basic rules of fuzzy logic to calculate partial truth values

5. sketch basic rules of temporal logic
6. implement predicates in a logic programming language
7. prove some simple non-standard logic theorems

Indicative Literature

- Bergmann, Merry. “An Introduction to Many-Valued and Fuzzy Logic: Semantics, Algebras, and Derivation Systems”, Cambridge University Press, April 2008.
- Sterling, Leon S., Ehud Y. Shapiro, Ehud Y. "The Art of Prolog", 2nd edition, MIT Press, March 1994.
- Fisher, Michael. “An Introduction to Practical Formal Methods Using Temporal Logic”, Wiley, Juli 2011.
- Baader, Franz. "The Description Logic Handbook: Theory Implementation and Applications", Cambridge University Press, 2nd edition, May 2010.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination — Duration: 60 min, Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.1 Causation and Correlation (perspective I)

Module Name			**Module Code**	**Level (type)**	**CP**
Causation and Correlation (perspective I)			CTNS-NSK-03	Year 2 (New Skills)	2.5
Module Components					
Number	Name			Type	CP
CTNS-03	Causation and Correlation			Lecture (online)	2.5
Module Coordinator Prof. Dr. Jules Coleman	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective for all UG students (one perspective must be chosen)	
Entry Requirements			**Frequency** Annually (Spring)	**Forms of Learning and Teaching** • Online lecture (17.5h) • Private study (45h)	
Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills	**Duration** 1 semester	**Workload** 62.5 hours	
Recommendations for Preparation					

Content and Educational Aims

In many ways, life is a journey. And also, as in other journeys, our success or failure depends not only on our personal traits and character, our physical and mental health, but also on the accuracy of our map. We need to know what the world we are navigating is actually like, the how, why and the what of what makes it work the way it does. The natural sciences provide the most important tool we have developed to learn how the world works and why it works the way it does. The social sciences provide the most advanced tools we have to learn how we and other human beings, similar in most ways, different in many others, act and react and what makes them do what they do. In order for our maps to be useful, they must be accurate and correctly reflect the way the natural and social worlds work and why they work as they do.

The natural sciences and social sciences are blessed with enormous amounts of data. In this way, history and the present are gifts to us. To understand how and why the world works the way it does requires that we are able to offer an explanation of it. The data supports a number of possible explanations of it. How are we to choose among potential explanations? Explanations, if sound, will enable us to make reliable predictions about what the future will be like, and also to identify many possibilities that may unfold in the future. But there are differences not just in the degree of confidence we have in our predictions, but in whether some of them are necessary future states or whether all of them are merely possibilities? Thus, there are three related activities at the core of scientific inquiry: understanding where we are now and how we got here (historical); knowing what to expect going forward (prediction); and exploring how we can change the paths we are on (creativity).

At the heart of these activities are certain fundamental concepts, all of which are related to the scientific quest to uncover immutable and unchanging laws of nature. Laws of nature are thought to reflect a causal nexus between a previous event and a future one. There are also true statements that reflect universal or nearly universal connections between events past and present that are not laws of nature because the relationship they express is that of a correlation between events. A working thermostat accurately allows us to determine or even to predict the temperature in the room in which it is located, but it does not explain why the room has the temperature it has. What then is the core difference between causal relationships and correlations? At the same time, we all recognize that given where we are now there are many possible futures for each of us, and even had our lives gone just the slightest bit differently than they have, our present state could well have been very different than it is. The relationship between possible pathways between events that have not materialized but could have is expressed through the idea of counterfactual.

Creating accurate roadmaps, forming expectations we can rely on, making the world a more verdant and attractive place requires us to understand the concepts of causation, correlation, counterfactual explanation, prediction, necessity, possibility, law of nature and universal generalization. This course is designed precisely to provide the conceptual tools and intellectual skills to implement those concepts in our future readings and research and ultimately in our experimental investigations, and to employ those tools in various disciplines.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students will be able to

1. formulate testable hypotheses that are designed to reveal causal connections and those designed to reveal interesting, important and useful correlations.
2. distinguish scientifically interesting correlations from unimportant ones.
3. apply critical thinking skills to evaluate information.
4. understand when and why inquiry into unrealized possibility is important and relevant.

Indicative Literature

Thomas S. Kuhn: The Structure of Scientific Revolutions, Nelson, fourth edition 2012;

Goodman, Nelson. Fact, fiction, and forecast. Harvard University Press, 1983;

Quine, Willard Van Orman, and Joseph Silbert Ullian. The web of belief. Vol. 2. New York: Random house, 1978.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.2 Causation and Correlation (perspective II)

Module Name			**Module Code**	**Level (type)**	**CP**
Causation and Correlation (perspective II)			CTNS-NSK-04	Year 2 (New Skills)	2.5
Module Components					
Number	Name			Type	CP
CTNS-04	Causation and Correlations (perspective II)			Lecture (online)	2.5
Module Coordinator Dr. Keivan Mallahi-Karai Dr. Eoin Ryan Dr. Irina Chiaburu	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective for all UG students (one perspective must be chosen)	
Entry Requirements Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills • Basic probability theory	**Frequency** Annually (Spring)	**Forms of Learning and Teaching** • Online lecture (17.5h) • Private study (45h)	
			Duration 1 semester	**Workload** 62.5 hours	
Recommendations for Preparation					

Content and Educational Aims

Causality or causation is a surprisingly difficult concept to understand. David Hume famously noted that causality is a concept that our science and philosophy cannot do without, but it is equally a concept that our science and philosophy cannot describe. Since Hume, the problem of cause has not gone away, and sometimes seems to get even worse (e.g., quantum mechanics confusing previous notions of causality). Yet, ways of doing science that lessen our need to explicitly use causality have become very effective (e.g., huge developments in statistics). Nevertheless, it still seems that the concept of causality is at the core of explaining how the world works, across fields as diverse as physics, medicine, logistics, the law, sociology, and history – and ordinary daily life – through all of which, explanations and predictions in terms of cause and effect remain intuitively central.

Causality remains a thorny problem but, in recent decades, significant progress has occurred, particularly in work by or inspired by Judea Pearl. This work incorporates many 20th century developments, including statistical methods – but with a reemphasis on finding the why, or the cause, behind statistical correlations –, progress in understanding the logic, semantics and metaphysics of conditionals and counterfactuals, developments based on insights from the likes of philosopher Hans Reichenbach or biological statistician Sewall Wright into causal precedence and path analysis, and much more. The result is a new toolkit to identify causes and build causal explanations. Yet even as we get better at identifying causes, this raises new (or old) questions about causality, including metaphysical questions about the nature of causes (and effects, events, objects, etc), but also questions about what we really use causality for (understanding the world as it is or just to glean predictive control of specific outcomes), about how causality is used differently in different fields and activities (is cause in physics the same as that in history?), and about how other crucial concepts relate to our concept of cause (space and time seem to be related to causality, but so do concepts of legal and moral responsibility).

This course will introduce students to the mathematical formalism derived from Pearl's work, based on directed acyclic graphs and probability theory. Building upon previous work by Reichenbach and Wright, Pearl defines a "a calculus of interventions" of "do-calculus" for talking about interventions and their relation to causation and counterfactuals. This model has been applied in various areas ranging from econometrics to statistics, where acquiring knowledge about causality is of great importance.

At the same time, the course will not forget some of the metaphysical and epistemological issues around cause, so that students can better critically evaluate putative causal explanations in their full context. Abstractly, such issues involve some of the same philosophical questions Hume already asked, but more practically, it is important to see how metaphysical and epistemological debates surrounding the notion of cause affect scientific practice, and equally if not more importantly, how scientific practice pushes the limits of theory. This course will look at various ways in which empirical data can be transformed into explanations and theories, including the variance approach to causality (characteristic of the positivistic quantitative paradigm), and the process theory of causality (associated with qualitative methodology). Examples and case studies will be relevant for students of the social sciences but also students of the natural/physical world as well.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students will

1. have a clear understanding of the history of causal thinking.
2. be able to form a critical understanding of the key debates and controversies surrounding the idea of causality.
3. be able to recognize and apply probabilistic causal models.
4. be able to explain how understanding of causality differs among different disciplines.
5. be able demonstrate how theoretical thinking about causality has shaped scientific practices.

Indicative Literature

Paul, L. A. and Ned Hall. Causation: A User's Guide. Oxford University Press 2013.

Pearl, Judea. Causality: Models, Reasoning and Inference. Cambridge University Press 2009

Pearl, Judea, Glymour Madelyn and Jewell, Nicolas. Causal Inference in Statistics: A Primer. Wiley 2016

llari, Phyllis McKay and Federica Russo. Causality: Philosophical Theory Meets Scientific Practice. Oxford University Press 2014.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment: Written examination | Duration/Length: 60 min

Weight: 100 %

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.3 Linear Model and Matrices

Module Name			Module Code	Level (type)	CP
Linear Model and Matrices			CTNS-NSK-05	Year 3 (New Skills)	5
Module Components					
Number	Name			Type	CP
CTNS-05	Linear models and Matrices			Seminar (online)	5
Module Coordinator Prof. Dr. Marc-Thorsten Hütt	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective	
Entry Requirements Pre-requisites ☒ Logic ☒ Causation & Correlation	Co-requisites ☒ none	Knowledge, Abilities, or Skills	**Frequency** Annually (Fall)	**Forms of Learning and Teaching** • Online lecture (35h) • Private Study (90h)	
			Duration 1 Semester	**Workload** 125 hours	
Recommendations for Preparation					

Content and Educational Aims

There are no universal 'right skills'. But the notion of linear models and the avenue to matrices and their properties can be useful in diverse disciplines to implement a quantitative, computational approach. Some of the most popular data and systems analysis strategies are built upon this framework. Examples include principal component analysis (PCA), the optimization techniques used in Operations Research (OR), the assessment of stable and unstable states in nonlinear dynamical systems, as well as aspects of machine learning.

Here we introduce the toolbox of linear models and matrix-based methods embedded in a wide range of transdisciplinary applications (part 1). We describe its foundation in linear algebra (part 2) and the range of tools and methods derived from this conceptual framework (part 3). At the end of the course, we outline applications to graph theory and machine learning (part 4). Matrices can be useful representations of networks and of system of linear equations. They are also the core object of linear stability analysis, an approach used in nonlinear dynamics. Throughout the course, examples from neuroscience, social sciences, medicine, biology, physics, chemistry, and other fields are used to illustrate these methods.

A strong emphasis of the course is on the sensible usage of linear approaches in a nonlinear world. We will critically reflect the advantages as well as the disadvantages and limitations of this method. Guiding questions are: How appropriate is a linear approximation of a nonlinear system? What do you really learn from PCA? How reliable are the optimal states obtained via linear programming (LP) techniques?

This debate is embedded in a broader context: How does the choice of a mathematical technique confine your view on the system at hand? How, on the other hand, does it increase your capabilities of analyzing the system (due to software available for this technique, the ability to compare with findings from other fields built upon the same technique and the volume of knowledge about this technique)?

In the end, students will have a clearer understanding of linear models and matrix approaches in their own discipline, but they will also see the full transdisciplinarity of this topic. They will make better decisions in their choice of data analysis methods and become mindful of the challenges when going from a linear to a nonlinear thinking.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. apply the concept of linear modeling in their own discipline
2. distinguish between linear and nonlinear interpretation strategies and understand the range of applicability of linear models
3. make use of data analysis / data interpretation strategies from other disciplines, which are derived from linear algebra
4. be aware of the ties that linear models have to machine learning and network theory

   Note that these four ILOs can be loosely associated with the four parts of the course indicated above

Indicative Literature

Part 1:

material from Linear Algebra for Everyone, Gilbert Strang, Wellesley-Cambridge Press, 2020

Part 2:

material from Introduction to Linear Algebra (5th Edition), Gilbert Strang, Cambridge University Press, 2021

Part 3:

Mainzer, Klaus. "Introduction: from linear to nonlinear thinking." Thinking in Complexity: The Computational Dynamics of Matter, Mind and Mankind (2007): 1-16.

material from Mathematics of Big Data: Spreadsheets, Databases, Matrices, and Graphs, Jeremy Kepner, Hayden Jananthan, The MIT Press, 2018

material from Introduction to Linear Algebra (5th Edition), Gilbert Strang, Cambridge University Press, 2021

Part 4:

material from Linear Algebra and Learning from Data, Gilbert Strang, Wellesley-Cambridge Press, 2019

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment: Written examination — Duration/Length: 120 min

Weight: 100 %

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.4 Complex Problem Solving

Module Name			**Module Code**	**Level (type)**	**CP**
Complex Problem Solving			CTNS-NSK-06	Year 3 (New Skills)	5
Module Components					
Number	Name			Type	CP
CTNS-06	Complex Problem Solving			Lecture (online)	5
Module Coordinator Marco Verweij	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective	
Entry Requirements			**Frequency** Annually (Fall)	**Forms of Learning and Teaching** • Online Lectures (35h) • Private Study (90h)	
Pre-requisites ☒ Logic ☒ Causation & Correlation	Co-requisites ☒ none	Knowledge, Abilities, or Skills • Being able to read primary academic literature • Willingness to engage in teamwork	**Duration** 1 semester	**Workload** 125 hours	

Recommendations for Preparation

Please read: Camillus, J. (2008). Strategy as a wicked problem. Harvard Business Review 86: 99-106; Rogers, P. J. (2008). Using programme theory to evaluate complicated and complex aspects of interventions. Evaluation, 14, 29–48.

Content and Educational Aims

Complex problems are, by definition, non-linear and/or emergent. Some fifty years ago, scholars such as Herbert Simon began to argue that societies around the world had developed an impressive array of tools with which to solve simple and even complicated problems, but still needed to develop methods with which to address the rapidly increasing number of complex issues. Since then, a variety of such methods has emerged. These include 'serious games' developed in computer science, 'multisector systems analysis' applied in civil and environmental engineering, 'robust decision-making' proposed by the RAND Corporation, 'design thinking' developed in engineering and business studies, 'structured problem solving' used by McKinsey & Co., 'real-time technology assessment' advocated in science and technology studies, and 'deliberative decision-making' emanating from political science.

In this course, students first learn to distinguish between simple, complicated and complex problems. They also become familiar with the ways in which a particular issue can sometimes shift from one category into another. In addition, the participants learn to apply several tools for resolving complex problems. Finally, the students are introduced to the various ways in which natural and social scientists can help stakeholders resolve complex problems. Throughout the course examples and applications will be used. When possible, guest lectures will be offered by experts on a particular tool for tackling complex issues. For the written, take-home exam, students will have to select a specific complex problem, analyse it and come up with a recommendation – in addition to answering several questions about the material learned.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. Identify a complex problem;
2. Develop an acceptable recommendation for resolving complex problems.
3. Understand the roles that natural and social scientists can play in helping stakeholders resolve complex problems;

Indicative Literature

Chia, A. (2019). Distilling the essence of the McKinsey way: The problem-solving cycle. Management Teaching Review 4(4): 350-377.

Den Haan, J., van der Voort, M.C., Baart, F., Berends, K.D., van den Berg, M.C., Straatsma, M.W., Geenen, A.J.P., & Hulscher, S.J.M.H. (2020). The virtual river game: Gaming using models to collaboratively explore river management complexity, Environmental Modelling & Software 134, 104855,

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C.S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. AMBIO: A Journal of the Human Environment 31(5): 437-440.

Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. American Economic Review 100(3): 641-72.

Pielke, R. Jr. (2007). The honest broker: Making sense of science in policy and politics. Cambridge: Cambridge University Press.

Project Management Institute (2021). A guide to the project management body of knowledge (PMBOK® guide).

Schon, D. A., & Rein, M. (1994). Frame reflection: Toward the resolution of intractable policy controversies. New York: Basic Books.

Simon, H. A. (1973). The structure of ill structured problems. Artificial Intelligence 4(3-4): 181-201.

Verweij, M. & Thompson, M. (Eds.) (2006). Clumsy solutions for a complex world. London: Palgrave Macmillan.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written examination Duration: 120 min

Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.5 Argumentation, Data Visualization and Communication (perspective I)

<table>
<tr><td colspan="3">Module Name
Argumentation, Data Visualization and Communication (perspective I)</td><td>Module Code
CTNS-NSK-07</td><td>Level (type)
Year 3
(New Skills)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-07</td><td colspan="3">Argumentation, Data Visualization and Communication (perspective I)</td><td>Lecture (online)</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jules Coleman,
Prof Dr. Arvid Kappas</td><td colspan="3">Program Affiliation

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory elective for all UG students (one perspective must be chosen)</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ Logic; ☒ Causation & Correlation
Co-requisites: ☒ none
Knowledge, Abilities, or Skills</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Online Lectures (35h)
• Private Study (90h)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125h</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">One must be careful not to confuse argumentation with being argumentative. The latter is an unattractive personal attribute, whereas the former is a requirement of publicly holding a belief, asserting the truth of a proposition, the plausibility of a hypothesis, or a judgment of the value of a person or an asset. It is an essential component of public discourse. Public discourse is governed by norms and one of those norms is that those who assert the truth of a proposition or the validity of an argument or the responsibility of another for wrongdoing open themselves up to good faith requests to defend their claims. In its most general meaning, argumentation is the requirement that one offer evidence in support of the claims they make, as well as in defense of the judgments and assessments they reach. There are different modalities of argumentation associated with different contexts and disciplines. Legal arguments have a structure of their own as do assessments of medical conditions and moral character. In each case, there are differences in the kind of evidence that is thought relevant and, more importantly, in the standards of assessment for whether a case has been successfully made. Different modalities of argumentation require can call for different modes of reasoning. We not only offer reasons in defense of or in support of beliefs we have, judgments we make and hypotheses we offer, but we reason from evidence we collect to conclusions that are warranted by them.

Reasoning can be informal and sometimes even appear unstructured. When we recognize some reasoning as unstructured yet appropriate what we usually have in mind is that it is not linear. Most reasoning we are familiar with is linear in character. From A we infer B, and from A and B we infer C, which all together support our commitment to D. The same form of reasoning applies whether the evidence for A, B or C is direct or circumstantial. What changes in these cases is perhaps the weight we give to the evidence and thus the confidence we have in drawing inferences from it.

Especially in cases where reasoning can be supported by quantitative data, wherever quantitative data can be obtained either directly or by linear or nonlinear models, the visualization of the corresponding data can become key in both, reasoning and argumentation. A graphical representation can reduce the complexity of argumentation and is considered</td></tr>
</table>

a must in effective scientific communication. Consequently, the course will also focus on smart and compelling ways for data visualization - in ways that go beyond what is typically taught in statistics or mathematics lectures. These tools are constantly developing, as a reflection of new software and changes in state of the presentation art. Which graph or bar chart to use best for which data, the use of colors to underline messages and arguments, but also the pitfalls when presenting data in a poor or even misleading manner. This will also help in readily identifying intentional mis-representation of data by others, the simplest to recognize being truncating the ordinate of a graph in order to exaggerate trends. This frequently leads to false arguments, which can then be readily countered.

There are other modalities of reasoning that are not linear however. Instead they are coherentist. We argue for the plausibility of a claim sometimes by showing that it fits in with a set of other claims for which we have independent support. The fit is itself the reason that is supposed to provide confidence or grounds for believing the contested claim.

Other times, the nature of reasoning involves establishing not just the fit but the mutual support individual items in the evidentiary set provide for one another. This is the familiar idea of a web of interconnected, mutually supportive beliefs. In some cases, the support is in all instances strong; in others it is uniformly weak, but the set is very large; in other cases, the support provided each bit of evidence for the other is mixed: sometimes strong, sometimes weak, and so on.

There are three fundamental ideas that we want to extract from this segment of the course. These are (1) that argumentation is itself a requirement of being a researcher who claims to have made findings of one sort or another; (2) that there are different forms of appropriate argumentation for different domains and circumstances; and (3) that there are different forms of reasoning on behalf of various claims or from various bits of evidence to conclusions: whether those conclusions are value judgments, political beliefs, or scientific conclusions. Our goal is to familiarize you with all three of these deep ideas and to help you gain facility with each.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students will be able to

1. Distinguish among different modalities of argument, e.g. legal arguments, vs. scientific ones.
2. Construct arguments using tools of data visualization.
3. Communicate conclusions and arguments concisely, clearly and convincingly.

Indicative Literature

- Tufte, E.R. (1985). The visual display of quantitative information. The Journal for Healthcare Quality (JHQ), 7(3), 15.
- Cairo, A (2012). The Functional Art: An introduction to information graphics and visualization. New Ridders.
- Knaflic, C.N. (2015). Storytelling with data: A data visualization guide for business professionals. John Wiley & Sons.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 120 (min)
Weight: 100%

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.6 Argumentation, Data Visualization and Communication (perspective II)

<table>
<tr><td colspan="3">Module Name

Argumentation, Data Visualization and Communication (perspective II)</td><td>Module Code
CTNS-NSK-08</td><td>Level (type)
Year 3
(New Skills)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-08</td><td colspan="3">Argumentation, Data Visualization and Communication (perspective II)</td><td>Lecture (online)</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jules Coleman,
Prof Dr. Arvid Kappas</td><td colspan="3">Program Affiliation

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory elective for all UG students (one perspective must be chosen)</td></tr>
<tr><td colspan="3">Entry Requirements

Pre-requisites: ☒ Logic
☒ Causation & Correlation

Co-requisites: ☒ none

Knowledge, Abilities, or Skills:
• ability and openness to engage in interactions
• media literacy, critical thinking and a proficient handling of data sources
• own research in academic literature</td><td>Frequency

Annually (Spring)

Duration

1 semester</td><td colspan="2">Forms of Learning and Teaching

• Online Lecture (35 hours)
• Tutorial of the lecture (10 hours)
• Private study for the lecture (80 hours)

Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">Content and Educational Aims
Humans are a social species and interaction is crucial throughout the entire life span. While much of human communication involves language, there is a complex multichannel system of nonverbal communication that enriches linguistic content, provides context, and is also involved in structuring dynamic interaction. Interactants achieve goals by encoding information that is interpreted in the light of current context in transactions with others. This complexity implies also that there are frequent misunderstandings as a sender’s intention is not fulfilled. Students in this course will learn to understand the structure of communication processes in a variety of formal and informal contexts. They will learn what constitutes challenges to achieving successful communication and to how to communicate effectively, taking the context and specific requirements for a target audience into consideration. These aspects will be discussed also in the scientific context, as well as business, and special cases, such as legal context – particularly with view to argumentation theory.

Communication is a truly transdisciplinary concept that involves knowledge from diverse fields such as biology, psychology, neuroscience, linguistics, sociology, philosophy, communication and information science. Students will learn what these different disciplines contribute to an understanding of communication and how theories from these fields can be applied in the real world. In the context of scientific communication, there will also be a focus on visual communication of data in different disciplines. Good practice examples will be contrasted with typical errors to facilitate successful communication also with view to the Bachelor’s thesis.</td></tr>
</table>

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. Analyze communication processes in formal and informal contexts.
2. Identify challenges and failures in communication.
3. Design communications to achieve specified goals to specific target groups.
4. Understand the principles of argumentation theory.
5. Use data visualization in scientific communications.

Indicative Literature

- Joseph A. DeVito: The Interpersonal Communication Book (Global edition, 16th edition), 2022
- Steven L. Franconeri, Lace M. Padilla, Priti Shah, Jeffrey M. Zacks, and Jessica Hullman: The Science of Visual Data Communication: What Works Psychological Science in the Public Interest, 22(3), 110–161, 2022
- Douglas Walton: Argumentation Theory – A Very Short Introduction. In: Simari, G., Rahwan, I. (eds) Argumentation in Artificial Intelligence. Springer, Boston, MA, 2009

Examination Type: Module Examination

Assessment Type: Digital submission of asynchronous presentation, including reflection

Duration/Length: Asynchronous/Digital submission

Weight: 100%

Scope: All intended learning outcomes of the module

Module achievement: Asynchronous presentation on a topic relating to the major of the student, including a reflection including concept outlining the rationale for how arguments are selected and presented based on a particular target group for a particular purpose. The presentation shall be multimedial and include the presentation of data

The module achievement ensures sufficient knowledge about key concepts of effective communication including a reflection on the presentation itself

Completion: To pass this module, the examination has to be passed with at least 45%%.

8.2.7 Agency, Leadership, and Accountability

<table>
<tr><td colspan="3">Module Name
Agency, Leadership, and Accountability</td><td>Module Code
CTNS-NSK-09</td><td>Level (type)
Year 3
(New Skills)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-09</td><td colspan="3">Agency, Leadership, and Accountability</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jules Coleman</td><td colspan="3">Program Affiliation

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory for CSSE
Mandatory elective for all other UG study programs</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ none
Co-requisites: ☒ none
Knowledge, Abilities, or Skills:</td><td>Frequency

Annually
(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Online Lectures (35h)
• Private Study (90h)</td></tr>
<tr><td>Duration</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">Content and Educational Aims

Each of us is judged by the actions we undertake and held to account for the consequences of them. Sometimes we may be lucky and our bad acts don't have harmful effects on others. Other times we may be unlucky and reasonable decisions can lead to unexpected or unforeseen adverse consequences for others. We are therefore held accountable both for choices and for outcomes. In either case, accountability expresses the judgment that we bear responsibility for what we do and what happens as a result. But our responsibility and our accountability in these cases is closely connected to the idea that we have agency.

Agency presumes that we are the source of the choices we make and the actions that result from those choices. For some, this may entail the idea that we have free will. But there is scientific world view that holds that all actions are determined by the causes that explain them, which is the idea that if we knew the causes of your decisions in advance, we would know the decision you would make even before you made it. If that is so, how can your choice be free? And if it is not free, how can you be responsible for it? And if you cannot be responsible, how can we justifiably hold you to account for it?

These questions express the centuries old questions about the relationship between free will and a determinist world view: for some, the conflict between a scientific world view and a moral world view.

But we do not always act as individuals. In society we organize ourselves into groups: e.g. tightly organized social groups, loosely organized market economies, political societies, companies, and more. These groups have structure. Some individuals are given the responsibility of leading the group and of exercising authority. But one can exercise authority over others in a group merely by giving orders and threatening punishment for non-compliance.

Exercising authority is not the same thing as being a leader? For one can lead by example or by encouraging others to exercise personal judgment and authority. What then is the essence of leadership?

The module has several educational goals. The first is for students to understand the difference between actions that we undertake for which we can reasonably held accountable and things that we do but which we are not responsible for. For example, a twitch is an example of the latter, but so too may be a car accident we cause as a result of a heart attack we</td></tr>
</table>

had no way of anticipating or controlling. This suggests the importance of control to responsibility. At the heart of personal agency is the idea of control. The second goal is for students to understand what having control means. Some think that the scientific view is that the world is deterministic, and if it is then we cannot have any personal control over what happens, including what we do. Others think that the quantum scientific view entails a degree of indeterminacy and that free will and control are possible, but only in the sense of being unpredictable or random. But then random outcomes are not ones we control either. So, we will devote most attention to trying to understand the relationships between control, causation and predictability.

But we do not only exercise agency in isolation. Sometimes we act as part of groups and organizations. The law often recognizes ways in which groups and organizations can have rights, but is there a way in which we can understand how groups have responsibility for outcomes that they should be accountable for. We need to figure out then whether there is a notion of group agency that does not simply boil down to the sum of individual actions. We will explore the ways in which individual actions lead to collective agency.

Finally we will explore the ways in which occupying a leadership role can make one accountable for the actions of others over which one has authority.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students will be able to

1. Understand and reflect how the social and moral world views that rely on agency and responsibility are compatible, if they are, with current scientific world views.
2. understand how science is an economic sector, populated by large powerful organizations that set norms and fund research agendas.
3. identify the difference between being a leader of others or of a group – whether a research group or a lab or a company – and being in charge of the group.
4. learn to be a leader of others and groups. Understand that when one graduates one will enter not just a field of work but a heavily structured set of institutions and that one's agency and responsibility for what happens, what work gets done, its quality and value, will be affected accordingly.

Indicative Literature

Hull, David L. "Science as a Process." Science as a Process. University of Chicago Press, 2010;

Feinberg, Joel. "Doing & deserving; essays in the theory of responsibility." (1970).

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written examination

Duration/Length: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module

Completion: To pass this module, the examination has to be passed with at least 45%

8.2.8 Community Impact Project

Module Name	Module Code	Level (type)	CP
Community Impact Project	CTNS-CIP-10	Year 3 (New Skills)	5

Module Components

Number	Name	Type	CP
CTNS-10	Community Impact Project	Project	5

Module Coordinator	Program Affiliation	Mandatory Status
CIP Faculty Coordinator	• CONSTRUCTOR Track Area	Mandatory elective

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Fall / Spring)	- Introductory, accompanying, and final events: 10 hours - Self-organized teamwork and/or practical work in the community: 115 hours
☒ at least 15 CP from CORE modules in the major	☒ None	• Basic knowledge of the main concepts and methodological instruments of the respective disciplines	**Duration** 1 semester	**Workload** 125 hours

Recommendations for Preparation

Develop or join a community impact project before the 5th or 6th semester based on the introductory events during the 4th semester by using the database of projects, communicating with fellow students and faculty, and finding potential companies, organizations, or communities to target.

Content and Educational Aims

CIPs are self-organized, major-related, and problem-centered applications of students' acquired knowledge and skills. These activities will ideally be connected to their majors so that they will challenge the students' sense of practical relevance and social responsibility within the field of their studies. Projects will tackle real issues in their direct and/or broader social environment. These projects ideally connect the campus community to other communities, companies, or organizations in a mutually beneficial way.
Students are encouraged to create their own projects and find partners (e.g., companies, schools, NGOs), but will get help from the CIP faculty coordinator team and faculty mentors to do so. They can join and collaborate in interdisciplinary groups that attack a given issue from different disciplinary perspectives.
Student activities are self-organized but can draw on the support and guidance of both faculty and the CIP faculty coordinator team.

Intended Learning Outcomes

The Community Impact Project is designed to convey the required personal and social competencies for enabling students to finish their studies at Constructor University as socially conscious and responsible graduates (part of the Constructor University's mission) and to convey social and personal abilities to the students, including a practical awareness of the societal context and relevance of their academic discipline.

1. By the end of this project, students will be able to
2. understand the real-life issues of communities, organizations, and industries and relate them to concepts in their own discipline;
3. enhance problem-solving skills and develop critical faculty, create solutions to problems, and communicate these solutions appropriately to their audience;
4. apply media and communication skills in diverse and non-peer social contexts;
5. develop an awareness of the societal relevance of their own scientific actions and a sense of social responsibility for their social surroundings;

6. reflect on their own behavior critically in relation to social expectations and consequences;
7. work in a team and deal with diversity, develop cooperation and conflict skills, and strengthen their empathy and tolerance for ambiguity.

Indicative Literature

Not specified

Usability and Relationship to other Modules

- Students who have accomplished their CIP (6th semester) are encouraged to support their fellow students during the development phase of the next year's projects (4th semester).

Examination Type: Module Examination

Project Assessment, not numerically graded (pass/fail)
Scope: All intended learning outcomes of the module

8.3 Language and Humanities Modules

8.3.1 Languages

The descriptions of the language modules are provided in a separate document, the "Language Module Handbook" that can be accessed from the Constructor University's Language & Community Center internet sites (https://constructor.university/student-life/language-community-center/learning-languages).

8.3.2 Humanities

8.3.2.1 Introduction to Philosophical Ethics

Module Name		**Module Code**	**Level (type)**	**CP**
Introduction to Philosophical Ethics		CTHU-HUM-001	Year 1	2.5
Module Components				
Number	Name		Type	CP
CTHU-001	Introduction to Philosophical Ethics		Lecture (online)	2.5
Module Coordinator Dr. Eoin Ryan	**Program Affiliation** • CONSTRUCTOR Track Area		**Mandatory Status** Mandatory elective	
Entry Requirements Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills	**Frequency** Annually (Fall or Spring)	**Forms of Learning and Teaching** • Online lectures (17.5 h) • Private Study (45h)
		Duration 1 semester	**Workload** 62.5 hours	

Recommendations for Preparation

Content and Educational Aims

The nature of morality – how to lead a life that is good for yourself, and how to be good towards others – has been a central debate in philosophy since the time of Socrates, and it is a topic that continues to be vigorously discussed. This course will introduce students to some of the key aspects of philosophical ethics, including leading normative theories of ethics (e.g. consequentialism or utilitarianism, deontology, virtue ethics, natural law ethics, egoism) as well as some important questions from metaethics (are useful and generalizable ethical claims even possible; what do ethical speech and ethical judgements actually do or explain) and moral psychology (how do abstract ethical principles do when realized by human psychologies). The course will describe ideas that are key factors in ethics (free will, happiness, responsibility, good, evil, religion, rights) and indicate various routes to progress in understanding ethics, as well as some of their difficulties.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. Describe normative ethical theories such as consequentialism, deontology and virtue ethics.
2. Discuss some metaethical concerns.
3. Analyze ethical language.
4. Highlight complexities and contradictions in typical ethical commitments.
5. Indicate common parameters for ethical discussions at individual and social levels.
6. Analyze notions such as objectivity, subjectivity, universality, pluralism, value.

Indicative Literature

Simon Blackburn, Being Good (2009)

Russ Shafer-Landay, A Concise Introduction to Ethics (2019)

Mark van Roojen, Metaethicas: A Contemporary Introduction (2015)

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination has to be passed with at least 45%

8.3.2.2 Introduction to the Philosophy of Science

Module Name Introduction to the Philosophy of Science			**Module Code** CTHU-HUM-002	**Level (type)** Year 1	**CP** 2.5
Module Components					
Number	Name			Type	CP
CTHU-002	Introduction to the Philosophy of Science			Lecture (online)	2.5
Module Coordinator Dr. Eoin Ryan	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective	
Entry Requirements Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills	**Frequency** Annually (Fall or Spring)	**Forms of Learning and Teaching** • Online lectures (17.5h) • Private Study (45h)	
			Duration 1 semester	**Workload** 62.5 hours	

Recommendations for Preparation

Content and Educational Aims

This humanities module will introduce students to some of the central ideas in philosophy of science. Topics will include distinguishing science from pseudo-science, types of inference and the problem of induction, the pros and cons of realism and anti-realism, the role of explanation, the nature of scientific change, the difference between natural and social sciences, scientism and the values of science, as well as some examples from philosophy of the special sciences (e.g., physics, biology).

The course aims to give students an understanding of how science produces knowledge, and some of the various contexts and issues which mean this process is never entirely transparent, neutral, or unproblematic. Students will gain a critical understanding of science as a human practice and technology; this will enable them both to better understand the importance and success of science, but also how to properly critique science when appropriate.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. Understand key ideas from the philosophy of science.
2. Discuss different types of inference and rational processes.
3. Describe differences between how the natural sciences, social sciences and humanities discover knowledge.
4. Identify ways in which science can be more and less value-laden.
5. Illustrate some important conceptual leaps in the history of science.

Indicative Literature

Peter Godfrey-Smith, Theory and Reality (2021)

James Ladyman, Understanding Philosophy of Science (2002)

Paul Song, Philosophy of Science: Perspectives from Scientists (2022)

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min

Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination must be passed with at least 45%.

8.3.2.3 Introduction to Visual Culture

Module Name Introduction to Visual Culture			Module Code CTHU-HUM-003	Level (type) Year 1	CP 2.5
Module Components					
Number	Name			Type	CP
CTHU-003	Introduction to Visual Culture			Lecture (online)	2.5
Module Coordinator Irina Chiaburu	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective	
Entry Requirements Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills •	**Frequency** Annually (Spring or Fall)	**Forms of Learning and Teaching** • Online Lecture	
			Duration 1 semester	**Workload** 62.5 h	
Recommendations for Preparation					

Content and Educational Aims

Of the five senses, the sense of sight has for a long time occupied the central position in human cultures. As John Berger has suggested this could be because we can see and recognize the world around us before we learn how to speak. Images have been with us since the earliest days of the human history. In fact, the earliest records of human history are images found on cave walls across the world. We use images to capture abstract ideas, to catalogue and organize the world, to represent the world, to capture specific moments, to trace time and change, to tell stories, to express feelings, to better understand, to provide evidence and more. At the same time, images exert their power on us, seducing us into believing in their 'innocence', that is into forgetting that as representations they are also interpretations, i.e., a particular version of the world.

The purpose of this course is to explore multiple ways in which images and the visual in general mediate and structure human experiences and practices from more specialized discourses, e.g., scientific discourses, to more informal and personal day-to-day practices, such as self-fashioning in cyberspace. We will look at how social and historical contexts affect how we see, as well as what is visible and what is not. We will explore the centrality of the visual to the intellectual activity, from early genres of scientific drawing to visualizations of big data. We will examine whether one can speak of visual culture of protest, look at the relationship between looking and subjectivity and, most importantly, ponder the relationship between the visual and the real.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. Understand a range of key concepts pertaining to visual culture, art theory and cultural analysis
2. Understand the role visuality plays in development and maintenance of political, social, and intellectual discourses
3. Think critically about images and their contexts
4. Reflect critically on the connection between seeing and knowing

Indicative Literature

- Berger, J., Blomberg, S., Fox, C., Dibb, M., & Hollis, R. (1973). Ways of seeing.
- Foucault, M. (2002). The order of things: an archaeology of the human sciences (Ser. Routledge classics). Routledge.
- Hunt, L. (2004). Politics, culture, and class in the French revolution: twentieth anniversary edition, with a new preface (Ser. Studies on the history of society and culture, 1). University of California Press.
- Miller, V. (2020). Understanding digital culture (Second). SAGE.
- Thomas, N. (1994). Colonialism's culture: anthropology, travel and government. Polity Press.

Usability and Relationship to other Modules	
Examination Type: Module Examination	
Assessment: Written examination	Duration/Length: 60 min. Weight: 100%
Scope: all intended learning outcomes	
Completion: To pass this module, the examination has to be passed with at least 45%	

9 Appendix

9.1 Intended Learning Outcomes Assessment-Matrix

Chemistry and Biotechnology					Gen. Biochemistry	Gen. and Inorganic Chem.	General Organic Chemistry	Intro. to Biotechnology	Industrial Biotechnology	Physical Chemistry	Adv. Inorganic Chemistry	Scientific Software & Db	Adv. Organic Chemistry	Adv. Org. & Analytical Chem. Lab	Bioprocess Engineering	Advanced Biotechnology Lab	Inorg. & Phys. Chem. Lab	Biotechnology in Action	Environ. Microbiol. and Biotech	Flourine in Organic Synthesis	Medicinal Chemistry	Organometallic Chemistry	Adv. Organic Synthesis	Internship/Start-up	Bachelor Thesis/Seminar	CT Methods	CT German Language and Humanities Modules	CT New Skills
Semester					1	1	2	2	3	3	4	4	4	3	4	3	4	6	6	6	5	5	6	5	6	1-4	1-2	3-6
Mandatory/mandatory elective					m	m	m	m	m	m	m	m	m	m	m	m	m	me	me	me	me	me	me	m	m	m	me	me
Credits					7.5	7.5	7.5	7.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	15	15	20	5	20
	Competencies*																											
Program Learning Outcomes	A	E	P	S																								
A1.recognize the fundamental properties, structures, and reactivity of chemical substances	x	x			x	x	x				x		x								x	x						
A2.explain the fundamental facts, principles, and theories for the principal areas of chemistry (analytical, organic, inorganic, and physical	x	x				x	x			x	x		x								x							
A3.apply physical principles to chemical and biotechnological concepts;	x	x								x				x		x	x	x	x	x		x				x		
A4.recognize basic biochemical patterns of the structure and reactivity of molecules in nature	x	x			x			x	x						x											x		
A5.apply calculational tools to quantitative problems in Chemistry and Biotechnology;	x	x			x			x	x	x					x	x		x								x		
A6.explain the concept of biomolecules and the use of biocatalysts for the synthesis of useful chemicals	x	x			x			x	x						x	x				x			x		x	x		
A7.identify possibilities to manipulate genes, enzyme activities, and metabolic pathways	x	x						x	x						x	x	x		x							x		
A8.explain the structure and genetic modification of microorganisms;	x	x						x	x										x									
B1.apply chemical principles to formulate and analyze analytical and synthetic chemical problems;	x	x				x	x			x	x		x	x					x	x					x	x		
B2.analyze and interpret experimental data, critically assess data in literature, and extract useful data from it	x	x								x		x		x		x	x		x				x			x		
B3.carry out directed research by selecting appropriate topics and procedures, and present the results	x	x																					x		x			
B4.demonstrate appreciation of chemical and biotechnological topics relevant to environmental issues	x	x	x			x	x									x	x	x										
B5.use their knowledge to view issues in chemistry and biotechnology from a global perspective;	x	x	x					x	x		x		x		x				x					x				
B6.reflect on the consequences of chemical and biotechnological activities on humanity and the environment	x	x	x					x	x										x									
C1.assess and manage the risks of chemical substances and laboratory procedures by evaluating their potential impact on the environment and the experimenter	x	x	x			x	x	x						x	x	x	x				x				x			
C2.assess and manage the risks of gene-modified organisms by evaluating their potential impact on the environment and the experimenter;	x	x	x					x	x						x		x								x			
C3.conduct standard laboratory procedures involved in synthetic, analytic, and instrumental work	x	x			x	x	x	x						x		x	x	x		x	x				x			
C4.operate a range of chemical and biotechnological instrumentation with adequate hands-on experiences	x	x				x	x	x						x			x						x		x			
D1.communicate effectively both orally and in writing with professionals and/or a lay audience		x	x	x																				x	x		x	x
D2.possess information technology skills, especially in the areas of information retrieval, literature search, and the use of library databases	x		x	x					x			x						x			x							
D3.work independently and collaborate effectively with other people in a team		x	x	x	x	x	x	x						x		x	x	x		x					x		x	x
D4.self-evaluate their own learning progress, and develop motivation and learning skills for lifelong learning		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	x
Assessment Type																												
Written examination					x	x	x	x	x	x	x		x		x	x		x	x	x	x					x	x	x
Term paper												x																
Essay																											x	
Project report																								x				
Poster presentation																												
Laboratory report					x	x	x							x			x											
Program Code																												
Oral examination																						x	x				x	
Presentation										x											x				x	x	x	x
Practical Assessments																												
Project Assessments																	x											x
Portfolio Assessments																												
Bachelor Thesis																									x			
Module achievements					x						x						x	x									x	x

*Competencies: A-scientific/academic proficiency; E-competence for qualified employment; P-development of personality; S-competence for engagement in society
A: Chemistry and Biotechnology Related Knowledge
B: Chemistry and Biotechnology Related Intellectual Skills
C: Chemistry and Biotechnology Related Practical Skills
D: Transferable Skills

Figure 3: Intended Learning Outcomes Assessment-Matrix